

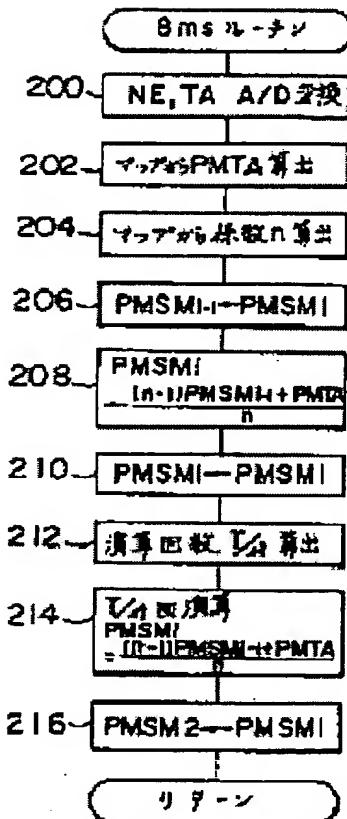
METHOD AND DEVICE FOR DETECTING INTAKE PIPE PRESSURE IN INTERNAL COMBUSTION ENGINE

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Abstract of JP2000027692

PROBLEM TO BE SOLVED: To predict an actual intake pipe pressure. **SOLUTION:** An engine speed NE and a throttle opening degree TA are read (200). An intake pipe pressure PMTA is computed in a steady-state, corresponding to NE and TA (202). A factor (n) relating to weighing is computed (204). A previously computed weight average value PMSMi-1 is read, and then, a weight average value PMSMi at the present time is computed from $PMSMi = ((n-1) \cdot PMSMi-1 + PMTA) / n$ (206 to 210). A time T msec from the present time to a time for predicting an intake pipe pressure is divided by a computation cycle period $\Delta t = 8$ msec in a routine so as to compute a frequency $T / \Delta t$ (212). With the repetitions of the above-mentioned computation by the frequency $T / \Delta t$ (214), an intake pipe pressure (intake pipe pressure in a state nearer the steady-state than the present time) is predicted at a time subsequent from the present time by T msec.



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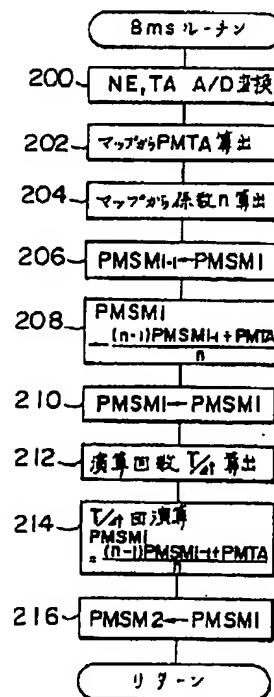
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(54) 【発明の名称】内燃機関の吸気管圧力検出方法および装置

(57) 【要約】

【課題】 実際の吸気管圧力を予測する。
 【解決手段】 機関回転速度N E及びスロットル開度T Aを取込む(200)。N EとT Aとに対応する定常状態での吸気管圧力P M T Aを演算する(202)。重み付けに関する係数nを演算する(204)。前回演算した加重平均値P M S M i - 1 を読み出して、P M S M i = ((n - 1) · P M S M i - 1 + P M T A) / nから、今回の加重平均値P M S M i を演算する(206~210)。現在時刻から吸気管圧力予測時点までの時間T msecを図16のルーチンの演算周期Δ t (= 8 msec)で除算することにより演算回数T / Δ tを演算する(212)。演算回数T / Δ t回上記演算を繰り返して実行して(214)、現在時刻からT msec先の吸気管圧力(現時点より定常状態に近い状態での吸気管圧力)を予測する。



【特許請求の範囲】

【請求項1】 スロットル開度と機関回転速度とに基づいて所定周期で定常状態での吸気管圧力を演算し、過渡時の吸気管圧力の変化に関する時定数と前記所定周期とを用いて重みに関する係数を演算し、過去に演算された加重平均値の重みを重くして、過去に演算された加重平均値と前記定常状態での吸気管圧力と前記重みに関する係数とを用いて現在の加重平均値を演算し、該演算時点から所定期間先の吸気管圧力の予測値を、該演算を繰り返し行うと共に該繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値を過去に演算された加重平均値として用いて、求める、内燃機関の吸気管圧力検出方法。

【請求項2】 スロットル開度の微分値及び機関回転速度の微分値の少なくとも一方を演算し、該微分値を用いて、前記演算を繰り返し行う各演算時点でのスロットル開度及び機関回転速度の少なくとも一方を予測し、前記演算を繰り返し行う各演算の際には前記予測されたスロットル開度及び前記予測されたき間回転速度の少なくとも一方を用いて、前記所定期間先の定常状態での吸気管圧力を予測する、

請求項1記載の内燃機関の吸気管圧力検出方法。

【請求項3】 スロットル開度及び機関回転速度、又は、定常状態での吸気管圧力及び機関回転速度を用いて、前記重みに関する係数を演算することを特徴とする請求項1記載の内燃機関の吸気管圧力検出方法。

【請求項4】 前記定常状態での吸気管圧力をPMTA、前記重みに関する係数をnとし、現在の実際の吸気管圧力PMSM_iを次式より演算することを特徴とする請求項1乃至請求項3の何れか1項に記載の内燃機関の吸気管圧力検出方法。

$$PMSM_i = ((n-1) \cdot PMSM_{i-1} + PMTA) / n$$

但し、PMSM_{i-1}は、前記繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値である。

【請求項5】 スロットル開度を検出するスロットル開度検出手段と、

機関回転速度を検出する回転速度検出手段と、前記検出されたスロットル開度と前記検出された機関回転速度とに基づいて所定周期で定常状態での吸気管圧力を演算する吸気管圧力演算手段と、過渡時の吸気管圧力の変化に関する時定数と前記所定周期とを用いて重みに関する係数を演算する重み係数演算手段と、

過去に演算された加重平均値の重みを重くして、過去に演算された加重平均値と前記定常状態での吸気管圧力と前記重みに関する係数とを用いて現在の加重平均値を演算し、該演算時点から所定期間先の吸気管圧力の予測値を、該演算を繰り返し行うと共に該繰り返し行う各演算の際に前回の演算により求めた現在の加重平均値を過去

に演算された加重平均値として用いて、求める吸気管圧力予測値予測手段と、を備えた内燃機関の吸気管圧力検出装置。

【請求項6】 スロットル開度の微分値及び機関回転速度の微分値の少なくとも一方を演算する演算手段と、前記演算された微分値を用いて、前記演算を繰り返し行う各演算時点でのスロットル開度及び機関回転速度の少なくとも一方を予測する予測手段と、をさらに含み、

10 前記吸気管予測値予測手段は、前記演算を繰り返し行う各演算の際には前記予測されたスロットル開度及び前記予測された機関回転速度の少なくとも一方を用いて、前記所定期間先の定常状態での吸気管圧力を予測する、請求項5記載の内燃機関の吸気管圧力検出装置。

【請求項7】 前記重み係数演算手段は、スロットル開度及び機関回転速度、又は、定常状態での吸気管圧力及び機関回転速度を用いて、前記重みに関する係数を演算することを特徴とする請求項5記載の内燃機関の吸気管圧力検出装置。

20 【請求項8】 前記吸気管圧力予測値予測手段は、前記定常状態での吸気管圧力をPMTA、前記重みに関する係数をnとした場合、前記現在の実際の吸気管圧力PMSM_iを次式より演算することを特徴とする請求項5乃至請求項7の何れか1項に記載の内燃機関の吸気管圧力検出装置。

$$PMSM_i = ((n-1) \cdot PMSM_{i-1} + PMTA) / n$$

但し、PMSM_{i-1}は、前記繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値である。

30 【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、内燃機関の吸気管圧力検出方法および装置に係り、より詳しくは、スロットル開度と機関回転速度とに基づいて吸気管圧力を検出する内燃機関の吸気管圧力検出方法および装置に関する。

【0002】

【従来の技術】 従来より、内燃機関の吸気管検出方法は、内燃機関の燃料噴射量制御方法などに用いられている。従来の内燃機関の燃料噴射量制御方法は、吸気管圧力と機関回転速度とを検出し、この検出された吸気管圧力と機関回転速度とに基づいて基本燃料噴射時間を演算し、この基本燃料噴射時間を吸気温や機関冷却水温等に応じて補正して燃料噴射時間を求め、この燃料噴射時間に相当する時間燃料噴射弁を開弁することにより燃料噴射量を制御するものである。この燃料噴射量制御方法においては、ダイヤフラム式の圧力センサを吸気管に取付け、機関脈動成分を除去するために時定数が3～5msecのフィルタを介して圧力センサ出力を処理することにより吸気管圧力を検出し、この検出された吸気管圧力と回

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転速度センサで検出された機関回転速度とに基づいて基本燃料噴射時間を演算するようにしている。

【0003】しかしながら、圧力センサのダイヤフラムによる応答遅れおよびフィルタの時定数による応答遅れが存在するため、加減速時等の過渡運転時には、実際の吸気管圧力の変動に対して検出された吸気管圧力の変動に時間遅れが生ずる。このため、加速時にはスロットル弁が急閉されて実際の吸気管圧力が急激に上昇するのに対して検出された吸気管圧力に時間遅れが生じ、実際の吸気管圧力より小さい値の吸気管圧力によって基本燃料噴射時間が演算されることになるため、空燃比がオーバリーンになり加速応答性が悪化すると共に排気エミッションが悪化する。逆に、減速時にはスロットル弁が急閉されることから吸気管圧力が急激に低下するため実際の吸気管圧力より大きな値の吸気管圧力によって基本燃料噴射時間が演算されることになり、空燃比がオーバリッチになってドライバビリティが悪化すると共に排気エミッシュンが悪化する。この空燃比のオーバリッチおよびオーバリーンを防止するために、加速増量や減速減量等の各種の増減量補正を行なっているが、過渡時には検出された吸気管圧力に時間遅れが存在するため全運転領域で完全に目標空燃比に制御することが不可能であった。

【0004】一方、実際の値に対して時間遅れのない物理量としてスロットル開度を用い、スロットル開度と機関回転速度とに基づいて基本燃料噴射時間を演算する方法（特開昭59-28031号公報）やスロットル開度と機関回転速度とに応じた吸気管圧力を記憶しておいて圧力センサより得られる信号に応じて排ガス再循環時の排ガスの分圧を考慮してこの吸気管圧力を補正して燃料噴射量を制御することが行なわれている（特開昭59-39948号公報）。

【0005】

【発明が解決しようとする課題】しかしながら、通常スロットル弁は圧力センサ取付位置および機関燃焼室から離れた上流側の位置に配置されており、スロットル弁を通過した空気が圧力センサ取付位置や機関燃焼室へ到達するまでに時間遅れが生じ、また、スロットル弁と吸気弁との間の容積のためスロットル開度は実吸入空気量の変化に対して位相が進むことになる。このため、スロットル開度と機関回転速度とで定められた吸気管圧力P(TA, NE)は図3に示すように実際の吸気管圧力Pより位相が進んだ値となる。なお、PMは圧力センサから得られる吸気管圧力である。また、図4に示すように、スロットル開度と機関回転速度とで定められた基本燃料噴射量TP(TA, NE)はスロットル開度の変化が実吸入空気量の変化に対して位相が進んでいるため要求燃料噴射量よりも多くなる。このためスロットル開度と機関回転速度とに基づいて燃料噴射量を制御すると、加速時には燃料噴射量が要求値より多くなって空燃比がオーバリッチになり、減速時には燃料噴射量が要求値よ

り少なくなって空燃比がオーバリーンになる。また、加速増量補正を行なった場合においても増量値は図4の斜線で示すようになり、上記の位相進みを補正することはできない。

【0006】本発明は上記問題点を解決すべく成されたもので、実際の吸気管圧力の変化に対して応答遅れのないスロットル開度を用いて位相進みおよび遅れのない吸気管圧力、すなわち実際の吸気管圧力を予測することができるようとした内燃機関の吸気管圧力検出方法および装置を提供することを目的とする。

【0007】

【課題を解決するための手段】上記目的達成のため請求項1記載の発明は、スロットル開度と機関回転速度とに基づいて所定周期で定常状態での吸気管圧力を演算し、過渡時の吸気管圧力の変化に関する時定数と前記所定周期とを用いて重みに関する係数を演算し、過去に演算された加重平均値の重みを重くして、過去に演算された加重平均値と前記定常状態での吸気管圧力と前記重みに関する係数とを用いて現在の加重平均値を演算し、該演算

20 時点から所定期間先の吸気管圧力の予測値を、該演算を繰り返し行うと共に該繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値を過去に演算された加重平均値として用いて、求めるものである。

【0008】請求項2記載の発明は、請求項1記載の発明において、スロットル開度の微分値及び機関回転速度の微分値の少なくとも一方を演算し、該微分値を用いて、前記演算を繰り返し行う各演算時点でのスロットル開度及び機関回転速度の少なくとも一方を予測し、前記演算を繰り返し行う各演算の際には前記予測されたスロットル開度及び前記予測されたき間回転速度の少なくとも一方を用いて、前記所定期間先の定常状態での吸気管圧力を予測するものである。

【0009】請求項3記載の発明は、請求項1記載の発明において、スロットル開度及び機関回転速度、又は、定常状態での吸気管圧力及び機関回転速度を用いて、前記重みに関する係数を演算するものである。

【0010】請求項4記載の発明は、請求項1乃至請求項3の何れか1項に記載の発明において、前記定常状態での吸気管圧力をPMTA、前記重みに関する係数をnとし、現在の実際の吸気管圧力PMSM_iを次式より演算することを特徴とする。

$$PMSM_i = ((n-1) \cdot PMSM_{i-1} + PMTA) / n$$

但し、PMSM_{i-1}は、前記繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値である。

【0012】請求項5記載の発明は、スロットル開度を検出するスロットル開度検出手段と、機関回転速度を検出する回転速度検出手段と、前記検出されたスロットル開度と前記検出された機関回転速度とに基づいて所定周期で定常状態での吸気管圧力を演算する吸気管圧力演算

手段と、過渡時の吸気管圧力の変化に関する時定数と前記所定周期とを用いて重みに関する係数を演算する重み係数演算手段と、過去に演算された加重平均値の重みを重くして、過去に演算された加重平均値と前記定常状態での吸気管圧力と前記重みに関する係数とを用いて現在の加重平均値を演算し、該演算時点から所定期間先の吸気管圧力の予測値を、該演算を繰り返し行うと共に該繰り返し行う各演算の際に前回の演算により求めた現在の加重平均値を過去に演算された加重平均値として用いて、求める吸気管圧力予測値予測手段と、を備えている。

【0013】請求項6記載の発明は、請求項5記載の発明において、スロットル開度の微分値及び機関回転速度の微分値の少なくとも一方を演算する演算手段と、前記演算された微分値を用いて、前記演算を繰り返し行う各演算時点でのスロットル開度及び機関回転速度の少なくとも一方を予測する予測手段と、をさらに含み、前記吸気管予測値予測手段は、前記演算を繰り返し行う各演算の際には前記予測されたスロットル開度及び前記予測された機関回転速度の少なくとも一方を用いて、前記所定期間先の定常状態での吸気管圧力を予測するものである。

【0014】請求項7記載の発明は、請求項5記載の発明において、前記重み係数演算手段は、スロットル開度及び機関回転速度、又は、定常状態での吸気管圧力及び機関回転速度を用いて、前記重みに関する係数を演算するものである。

* 【0015】請求項8記載の発明は、請求項5乃至請求項7の何れか1項に記載の発明において、前記吸気管圧力予測値予測手段は、前記定常状態での吸気管圧力をPMTA、前記重みに関する係数をnとした場合、前記現在の実際の吸気管圧力PM_{SM}を次式より演算するものである。

$$【0016】 PM_{SM} = ((n-1) \cdot PM_{SM_{-1}} + PMTA) / n$$

但し、PM_{SM_{-1}}は、前記繰り返し行う各演算の際の10前回の演算により求めた現在の加重平均値である。

【0017】最初に、参考として、実際の吸気管圧力を求める原理について説明する。図1に示すように、スロットル弁T_hからサージタンクSを介して機関Eの吸気弁までの吸気系を考え、吸気系内の空気の圧力（吸気管絶対圧力）をP [mmHgabs.]、吸気系の容積をV

[l]、吸気系内に存在する空気の重量をQ [g]、吸気系内の空気の絶対温度をT [°K]、大気圧をP_c

[mmHgabs.] するとと共に、吸気系から機関Eの燃焼室に吸入される単位時間当たりの空気重量を△Q₁ [g/sec]

20 20△t]、スロットル弁T_hを通過して吸気系内に吸入される単位時間当たりの空気重量を△Q₂ [g/sec] とし、微小時間△t内に吸気系の空気の重量が(△Q₂-△Q₁)・△t変化し、このとき吸気系内の空気の圧力が△P変化したものとして、吸気系内の空気にボイル・シャルルの法則を適用すると以下の(1)式に示すようになる。

【0018】

【数1】

$$(P + \Delta P) V = \{ Q + (\Delta Q_2 - \Delta Q_1) \Delta t \} RT \quad \dots (1)$$

【0019】ただし、Rは気体定数である。

【0020】一方、PV=Q·R·Tであるから上記

(1)式を変形すると、以下の(2)式が得られる。※

$$\frac{\Delta P}{\Delta t} = (\Delta Q_2 - \Delta Q_1) \frac{RT}{V} \quad \dots (2)$$

【0022】ここで、流量係数をψ、スロットル弁の開口面積（スロットル開度）をAとするとスロットル弁を通ずる単位時間当たりの空気重量△Q₂は以下の

(3)式で表わされ、行程容積をV_S、機関回転速度40【数3】をNE [rpm]、吸入効率をηとすると機関の燃焼室★

$$\Delta Q_2 = \psi \cdot A \sqrt{P_c - P} \quad \dots (3)$$

$$\Delta Q_1 = \frac{1}{2} \cdot V_s \cdot \frac{NE}{60} \cdot \eta \cdot P \cdot \frac{1}{RT} \quad \dots (4)$$

【0024】上記(3)、(4)式を(2)式に代入する
と次の(5)式が得られる。

★に吸入される単位時間当たりの空気重量△Q₁は以下の(4)式で表わされる。

【0023】

【数2】

【数3】

【0025】

【数4】

$$\frac{\Delta P}{\Delta t} = \frac{RT}{V} \phi A \sqrt{P_c - P}$$

$$= \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot P \quad \dots (5)$$

【0026】ここで、 $\Delta t \rightarrow 0$ の極限をとると、 * 【数5】

【0027】 *

$$\frac{dP}{dt} = \frac{RT}{V} \phi A \sqrt{P_c - P}$$

$$= \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot P \quad \dots (6)$$

【0028】となる。

(※微小値) を代入すると、以下の(7)式が得られる。

【0029】今、圧力 P_0 ($\neq PC$) 近傍での応答を

【0030】

考えて圧力が P_0 から $P_0 + P$ に変化したものとし

【数6】

て、上記(6)式のPに代えて $P_0 + P$ (ただし、Pは※

$$\frac{dP}{dt} = \frac{RT}{V} \phi A \sqrt{P_c - P_0 - P}$$

$$= \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot (P_0 + P)$$

$$\dots (7)$$

【0031】ここで、

★ 【数7】

【0032】 *

$$\sqrt{P_c - P_0 - P} = \sqrt{P_c - P_0} \left(1 - \frac{P}{P_c - P_0} \right)^{\frac{1}{2}}$$

$$= \sqrt{P_c - P_0} \left[1 - \frac{1}{2} \frac{P}{P_c - P_0} \right]$$

$$= \sqrt{P_c - P_0} - \frac{1}{2} \frac{P}{\sqrt{P_c - P_0}}$$

$$\dots (8)$$

【0033】であるから、上記(7)式は以下の(9)式
のようになる。

【0034】

【数8】

$$\begin{aligned}
 \frac{dP}{dt} &= -\frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &= -\frac{1}{2} \frac{RT}{V} \phi A \frac{P}{\sqrt{P_c - P_0}} \\
 &= -\frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta (P_0 + P) \\
 &= -\frac{1}{2} \left[\frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \right. \\
 &\quad \left. + \frac{RT \phi A}{V \sqrt{P_c - P_0}} \right] P \\
 &+ \frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta P_0
 \end{aligned}$$

… (9)

【0035】ここで、

* 【数9】

【0036】

$$\begin{aligned}
 a &= \frac{1}{2} \left[\frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \right. \\
 &\quad \left. + \frac{RT \phi A}{V \sqrt{P_c - P_0}} \right] \cdots (10)
 \end{aligned}$$

$$\begin{aligned}
 b &= \frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta P_0 \cdots (11)
 \end{aligned}$$

【0037】とすると、上記(9)式は次のようになる。

※【0039】上記(12)式を次の(13)式のように変形して両辺を積分し、積分定数をCとすると以下の(14)式が得られる。

【0038】

【数10】

$$\frac{dP}{dt} = -aP + b \cdots (12)$$

【0040】

【数11】

※40

$$\frac{dP}{-aP + b} = dt \cdots (13)$$

$$-\frac{1}{a} \log (-aP + b) = t + C \cdots (14)$$

【0041】ここでt=0のときPの初期値はP.0であるから上記(14)式より積分定数Cは次のようになる。

【0042】

【数12】

$$C = -\frac{1}{a} \ell \circ g (-a P_0 + b) \dots 05$$

【0043】上記(14)式と(15)式からPを求める
次のようになる。

* 【0044】

* 【数13】

$$P = \frac{b}{a} - \left(\frac{b}{a} - P_0 \right) \cdot e^{-at} \dots 06$$

【0045】ただし、eは自然対数の底である。

【0046】従って、スロットル弁の開口面積Aすなわちスロットル開度TA、機関回転速度NEおよびスロットル開度変化時点からの経過時間tを測定して上記(16)式に代入すれば、実際の吸気管圧力Pを求めることができる。そして、このようにして求めた実際の吸気管圧力Pと機関回転速度NEとに基づいて、例えば以下の式に示す演算を行なって基本燃料噴射時間TPを求め、この基本燃料噴射時間TPを吸気温や機関冷却水温等に応じて補正して燃料噴射時間を求め、この燃料噴射時間に相当する時間燃料噴射弁を開弁することにより機関が要求する量の燃料を噴射することができる。

【0047】

【数14】

$$TP = K \cdot \sqrt{P} / NE$$

【0048】ただし、Kは定数である。

【0049】ところで、上記(16)式の吸気管圧力Pをグラフで表わすと図2に示すようになり、t=0でP=P0、t→∞の極限(定常状態)ではP=b/a(定常状態での吸気管圧力PMTA)となる1次遅れ要素の出力である。従って、スロットル開度TAと機関回転速度NEとに基づいて定常状態での吸気管圧力PMTAを演算し、定常状態での吸気管圧力PMTAを以下の(17)式の伝達関数G(s)で表わされる1次遅れ要素で処理することにより実際の吸気管圧力を演算するよにしてよい。

【0050】

【数15】

$$G(s) = \frac{1}{Ts + 1} \dots 07$$

【0051】ただし、sはラプラス変換の演算子、Tは時定数である。

【0052】すなわち、所定周期毎にスロットル開度と機関回転速度とに基づいて定常状態での吸気管圧力を演算し、演算された定常状態での吸気管圧力を1次遅れ要素で処理することにより前記経過時間を変数とする吸気管圧力を演算することもできる。

【0053】このように、実際の吸気管圧力を予測してこの吸気管圧力と機関回転速度とに基づいて燃料噴射量を制御しているので、実際の吸入空気量に応じた量の燃

料を噴射することができ、これによって空燃比を目標空燃比に制御して過渡時の空燃比のオーバリッチ、オーバリーンを防止することができる。

【0054】次に、図6を参照して、他の参考例を説明する。図6に示すように、スロットル開度検出手段で検出されたスロットル開度TAと回転速度検出手段で検出された機関回転速度とに基づいて吸気管圧力演算手段Aによって定常状態での吸気管圧力PMTAが演算される。吸気管圧力演算手段Aによって演算された定常状態での吸気管圧力PMTAは、補正手段Bによって過渡時の吸気管圧力の応答遅れ分の補正が行なわれる。この補正手段としては1次遅れ要素を用いることができる。補正手段Bによって補正された吸気管圧力は基本燃料噴射時間演算手段Cに入力され、基本燃料噴射時間演算手段に入力されている機関回転速度NEとに基づいて基本燃料噴射時間TPが演算される。そして、基本燃料噴射時間TPに基づいて燃料噴射量制御手段によって燃料噴射量が制御される。

【0055】このように、圧力センサやフィルタを用いていないので、構造簡単かつ精度よく実際の吸気管圧力を予測して機関が要求する量の燃料を噴射することができる。

【0056】次に、請求項1記載の発明の具体的な作用を説明する。

【0057】本発明では、スロットル開度と機関回転速度とに基づいて所定周期で定常状態での吸気管圧力を演算し、過渡時の吸気管圧力の変化に関する時定数と前記所定周期とを用いて重みに関する係数を演算する。

【0058】そして、過去に演算された加重平均値の重みを重くして、過去に演算された加重平均値と前記定常状態での吸気管圧力と前記重みに関する係数とを用いて現在の加重平均値を演算し、該演算時点から所定期間先の吸気管圧力の予測値を、該演算を繰り返し行うと共に該繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値を過去に演算された加重平均値として用いて、求める。

【0059】即ち、例えば、所定期間を所定周期で除算することにより得られた所定回数だけ上記加重平均値の演算を繰り返せば、所定期間先の吸気管圧力を求めることができる。また、例えば、所定期間として演算時点から機関燃焼室に吸入される空気量が確定するまでの期間を取れば、吸入空気量が確定する時点での実際の吸気管

圧力を予測することができる。

【0060】なお、上記予測された所定期間先の吸気管圧力の予測値と機関回転速度とに基づいて基本燃料噴射時間を演算し、この演算結果に基づいて燃料噴射量を制御するようにしてもよい。

【0061】ここで、請求項2のように、スロットル開度の微分値及び機関回転速度の微分値の少なくとも一方を演算し、該微分値を用いて、前記演算を繰り返し行う各演算時点でのスロットル開度及び機関回転速度の少なくとも一方を予測し、前記演算を繰り返し行う各演算の際には前記予測されたスロットル開度及び前記予測された回転速度の少なくとも一方を用いて、前記所定期間先の定常状態での吸気管圧力を予測するようにしてもよい。

【0062】この場合、所定期間の間にスロットル開度と機関回転速度との少なくともいずれか一方が変化して定常状態での吸気管圧力が変化する場合でも、所定期間先の定常状態での吸気管圧力を予測するので、演算時点から所定期間先の吸気管圧力の予測値をさらに高精度に*

$$\frac{1}{T} \int_0^t e^{-\frac{t}{T}} d t = y(t) \quad \dots (18)$$

$$\frac{1}{T} \int_0^t \{x(t) - y(t)\} d t = y(t) \quad \dots (19)$$

$$\begin{aligned} & \frac{1}{T} \int_{t_1}^{t_2} \{x(t) - y(t)\} d t \\ & + \frac{1}{T} \int_0^{t_1} \{x(t) - y(t)\} d t = y(t) \end{aligned}$$

... (20)

【0068】ここで、 t_2 を現在の演算タイミング、 t_1 を過去の演算タイミングとすると次の(21)式が得られる。

$$\begin{aligned} & \frac{1}{T} (t_2 - t_1) \cdot (x(t_2) - y(t_1)) \\ & + y(t_1) = y(t_2) \quad \dots (21) \end{aligned}$$

【0070】上記(21)において、 $x(t_2)$ を定常状態での吸気管圧力PMTA、 $y(t_2)$ を現在の実際の吸気管圧力PM_{SMi}、 $y(t_1)$ を過去の実際の吸気管圧力PM_{SMi-1}、 $t_2 - t_1 (= \Delta t)$ を演算周期とす

*予測することができる。

【0063】また、請求項3のように、スロットル開度及び機関回転速度、又は、定常状態での吸気管圧力及び機関回転速度を用いて、前記重みに関する係数を演算するようにしてもよい。

【0064】更に、請求項4のように、前記定常状態での吸気管圧力をPMTA、前記重みに関する係数をnとし、現在の実際の吸気管圧力PM_{SMi}を次式(後述する(23)式)より演算するようにしてもよい。

10 【0065】 $PM_{SMi} = ((n-1) \cdot PM_{SMi-1} + PM_{TA}) / n$ 但し、 PM_{SMi-1} は、前記繰り返し行う各演算の際の前回の演算により求めた現在の加重平均値である。

【0066】次に、本発明の原理を説明する。1次遅れ要素をプロツク図で表わすと図5に示すようになり、入力を $x(t)$ とし、出力を $y(t)$ とし、時定数をTとする、図5の入出力の関係は以下の式で表わされる。

【0067】

【数16】

※【0069】

【数17】

※

れば、

【0071】

【数18】

$$\frac{15}{\Delta t} \quad (PMTA - PMSM_{i-1})$$

$$+ PMSM_{i-1} = PMSM_i \dots (22)$$

【0072】となり、 $T/\Delta t = n$ とすると、以下の(2) * 【0073】
3)式が得られる。

$$PMSM_i = \frac{(n-1) \cdot PMSM_{i-1} + PMTA}{n}$$

… (23)

【0074】すなわち、上記(23)式は、過去の実際の吸気管圧力 $PMSM_{i-1}$ の重みを $n-1$ とし、定常状態での吸気管圧力 $PMTA$ の重みを 1 とした加重平均を求めることにより、現在の実際の吸気管圧力 $PMSM_i$ を演算することができる事を示している。また、重みに関する係数 n は時定数 T と演算周期 Δt との比で求められる。

【0075】従って、スロットル開度と機関回転速度に基づいて所定周期 Δt で定常状態での吸気管圧力 $PMTA$ を演算し、過渡時の吸気管圧力の変化に関する時定数 T と所定周期 Δt とで重みに関する係数 n を演算し、過去に演算された加重平均値 $PMSM_{i-1}$ の重みを重くして過去に演算された加重平均値 $PMSM_{i-1}$ と定常状態での吸気管圧力 $PMTA$ と重みに関する係数 n とで上記(23)式に従って加重平均値 $PMSM_i$ を演算すれば、現在の実際の吸気管圧力が求められることになる。

【0076】そして、上記のようにして演算された加重平均値(現在の実際の吸気管圧力)と機関回転速度に基づいて基本燃料噴射時間を演算し、演算された基本燃料噴射時間に基づいて燃料噴射量を制御するようにしてもよい。

【0077】なお、上記(10)、(16)式から理解されるように、時定数 $T = 1/a$ は機関回転速度 N_E が大きくなる程小さくなり、スロットル開度 TA が大きくなる程小さくなる。このように、時定数はスロットル開度 TA と機関回転速度 N_E を変数とする関数で表わされる。従って演算周期 Δt を一定とすれば、重みに関する係数 n はスロットル開度 TA と機関回転速度 N_E とを変数とする関数で定めることができる。なお、スロットル開度 TA と機関回転速度 N_E とで定常状態での吸気管圧力 $PMTA$ が一義的に定まるから、スロットル開度 TA と機関回転速度 N_E とに代えて定常状態での吸気管圧力 $PMTA$ と機関回転速度 N_E とに応じて重みに関する係数 n を定めるようにしてもよい。

【0078】ところで、機関燃焼室に供給される空気量が確定するのは、吸気終了時点すなわち吸気弁閉弁時である。しかしながら、燃料噴射時間を演算するために所

定時間必要であると共に、燃料噴射弁から噴射された燃料が燃焼室に到達するまでに所定の飛行時間が必要であり、燃焼室に供給される空気量が確定したときに燃料噴射量を演算すると時間遅れが生じるため、従来では、燃焼室に供給される空気量が確定する前の吸気管圧力を用いて基本燃料噴射時間を演算している。このため、実際に燃焼室内に吸入された空気量に適合した量の燃料が噴射されなくなり、加速時には吸入空気量が確定する吸気管圧力より小さい値の吸気管圧力によって燃料噴射量が制御されるため、空燃比がリーンとなり、減速時には吸入空気量が確定する吸気管圧力より大きい値の吸気管圧力によって燃料噴射量が制御されるため、空燃比がリッチとなる。

【0079】一方、上記(23)式においてスロットル開度 TA と機関回転速度 N_E とが変化しないものと仮定すると、加重平均値演算時から吸入空気量が確定するまでの間、すなわち加重平均値演算時から所定時間先までの間

20 定常状態での吸気管圧力 $PMTA$ は一定である。従って、上記(23)式の加重平均値を繰り返し演算することによって吸入空気量確定時の実際の吸気管圧力を予測することができる。このため本発明では、定常状態での吸気管圧力を演算した時点から機関に吸入される空気量が確定するまでの時間を演算周期 Δt で除算することにより演算回数を求め、この演算回数だけ上記(23)式の加重平均の演算を繰り返すことにより、機関に吸入される空気量が確定する時点での加重平均値すなわち機関に吸入される空気量が確定する時点での実際の吸気管圧力を予測して燃料噴射量を制御するのが好ましい。

【0080】なお、上記では燃料噴射時間演算時から機関に吸入される空気量が確定するまでの間スロットル開度と機関回転速度とが変化しないものと仮定したが、スロットル開度や機関回転速度が変化する場合には、燃料噴射時間演算時でのスロットル開度の微分値および/または機関回転速度の微分値を用いて次の燃料噴射時間演算時点でのスロットル開度および/または機関回転速度を予測して、吸入空気量が確定するときの定常状態での吸気管圧力を予測し、上記のように加重平均値の演算を繰り返して実際の吸気管圧力を予測すれば、スロットル

開度や機関回転速度変動時の実際の吸気管圧力の予測値の精度が更に向上する（上記請求項2記載の発明参照）。

【0081】また、燃料噴射弁から噴射された燃料は、インテークマニホールド内壁面等の機関壁面に付着して噴射された燃料の全てが燃焼室に供給されないので、この燃料付着分を補正して燃料噴射量を制御するのが好ましい。この燃料付着量は、吸気管圧力の大きさに依存し、吸気管圧力が小さいと燃料の蒸発量が多くなるため燃料付着量は少なくなり、吸気管圧力が大きいと燃料の蒸発量が少なくなるため燃料付着量は多くなる。このため本態様では、加重平均によって演算された実際の吸気管圧力から機関壁面への燃料付着量の変化量を予測し、この変化量に相当する量の燃料噴射量を補正して機関に吸入される実際の吸入空気量に対応した量の燃料を機関に供給するのが好ましい。なお、燃料の壁面への付着量は機関温度や機関回転速度によっても変化する（機関温度が高いと燃料の蒸発量が多くなるため燃料付着量は少なくなり、機関回転速度が速くなると空気流速が速くなつて蒸発量が多くなるため燃料付着量は少なくなる）ため、機関温度や機関回転速度の関数として燃料付着量の変化量を定めるようにしても良く、また壁面への燃料付着量は瞬時に安定しないため燃料噴射量の補正量を時間減衰させて今回噴射したときの燃料付着量を次回以降の噴射に反映させるようにしても良い。

【0082】以上説明したように本発明においては、所定周期で加重平均値を演算することにより実際の吸気管圧力を予測しているため、スロットル開度変化時点からの経過時間を計測することなく実際の吸気管圧力を予測することができる。

【0083】これによって過渡時においても空燃比を目標空燃比に制御すれば、加速応答性、ドライバビリティおよび排気エミッション等の悪化を防止することができる。

【0084】なお、請求項5～請求項8記載の発明はそれぞれ、請求項1～請求項4記載の発明と同様の作用・効果を奏るので、その説明を省略する。

【0085】

【発明の実施の形態】以下図面を参照して本発明の実施の形態を詳細に説明する。図7は本実施の形態に係る内燃機関の概略図である。

【0086】エアクリーナ（図示せず）の下流側にはスロットル弁8が配置されている。このスロットル弁8には、スロットル弁8の開度を検出するスロットル開度センサ10が取付けられている。スロットル開度センサ10は、図8の等価回路に示すように、スロットル弁8の回動軸に固定された接触子10Bと一端に電源が接続されかつ他端が接地された可変抵抗10Aとで構成されており、スロットル弁8の開度が変化するに伴って、接触子10Bと可変抵抗10Aとの接觸状態が変化し、スロ

ットル弁8の開度に応じた電圧が接触子10Bから得られるように構成されている。スロットル弁8の上流側の吸気管壁には、吸入空気の温度を検出するサーミスタで構成された温度センサ14が取付けられている。スロットル弁8の下流側にはサージタンク12が配置されており、サージタンク12はインテークマニホールド18、吸気ポート22および吸気弁23を介して機関本体20の燃焼室25に連通されている。このインテークマニホールド24には、各気筒に対応するように燃料噴射弁24が取付けられており、各気筒独立にまたは各気筒グループ毎にまたは全気筒一斉に燃料を噴射できるように構成されている。

【0087】燃焼室25は、排気弁27、排気ポート26およびエキゾーストマニホールド28を介して三元触媒を充填した触媒装置（図示せず）に連通されている。このエキゾーストマニホールド28には、排ガス中の残留酸素濃度を検出して理論空燃比に対応する値を境に反転した信号を出力するO2センサ30が取付けられている。

【0088】シリングプロツク32には、ウォータージャケット内に突出するように機関温度を代表する機関冷却水温を検出するサーミスタ等で構成された冷却水温センサ34が取付けられている。シリングプロツク36には、各々の燃焼室25内に突出するように点火プラグ38が取付けられている。点火プラグ38はデイストリビュータ40および点火コイルを備えたイグナイタ42を介してマイクロコンピュータ等で構成された制御回路44に接続されている。デイストリビュータ40には、デイストリビュータシャフトに固定されたシグナルロータとデイストリビュータハウジングに固定されたピツクアップとで各々構成された気筒判別センサ46および回転角センサ48が取付けられている。気筒判別センサ46は、例えば720°C A毎に気筒判別信号を出し、回転角センサ48は、例えば30°C A毎に回転角信号を出力する。そして、この回転角信号の周期から機関回転速度を演算することができる。

【0089】マイクロコンピュータ等で構成された制御回路44は、図9に示すように、マイクロプロセッセンジユニット（MPU）60、リード・オンリ・メモリ（ROM）62、ランダム・アクセス・メモリ（RAM）64、バツクアップRAM（BU-RAM）66、入出力ポート68、入力ポート70、出力ポート72、74およびこれらを接続するデータバスやコントロールバス等のバス75を備えている。入出力ポート68には、アナログ-デジタル（A/D）変換器78およびマルチブレクサ80が順に接続されており、このマルチブレクサ80には、バツファ82を介して吸気温センサ14が接続されると共に、バツファ84およびバツファ85をそれぞれ介して水温センサ34およびスロットル開度センサ10が接続されている。また、入出力ポート6

8は、A/D変換器78およびマルチプレクサ80に接続されて、MPUからの制御信号に応じて吸気温センサ14、水温センサ34及びスロットル開度センサ10出力を順次所定周期でA/D変換するように制御する。

【0090】入力ポート70には、コンパレータ88およびバッファ86を介してO2センサ30が接続されると共に波形整形回路90を介して気筒判別センサ46および回転角センサ48が接続されている。そして、出力ポート72は駆動回路92を介してイグナイタ42に接続され、出力ポート74は駆動回路94を介して燃焼室24に接続されている。

【0091】上記ROM62には、以下で説明する制御ルーチンのプログラムや図10に示すスロットル開度TAと機関回転速度NEとで定められた定常状態での吸気管圧力PMTAのマップ、図11に示す機関回転速度NEと定常状態での吸気管圧力PMTA（またはスロットル開度TA）とで定められた重みに関する係数nのマップ、および実際の吸気管圧力PMSMと機関回転速度NEとで定められた基本燃料噴射時間TPのマップが予め記憶されている。図10に示す定常状態での吸気管圧力PMTAのマップは、スロットル開度TAと機関回転速度NEとを設定し、設定したスロットル開度TAと機関回転速度NEに対応する吸気管圧力を測定し、吸気管圧力が安定したときの値を用いることにより作成される。図11に示す重みに関する係数nのマップは、スロットル弁をステップ状に開いたときの吸気管圧力の応答（インデシャル応答）時の時定数Tを測定し、この測定値と図13に示す演算ルーチンの実行周期 Δt secから $T/\Delta t$ （ $\approx n$ ）を機関回転速度NEと実際の吸気管圧力PMTA（またはスロットル開度TA）とに対応して求めることにより作成される。そして図12の基本燃料噴射時間TPのマップは、機関回転速度と吸気管圧力を設定し目標空燃比となる基本燃料噴射時間TPを測定することにより作成される。

【0092】次に、図13に示す燃料噴射時間演算ルーチンについて説明する。このルーチンは、所定時間（例えば、8msec）毎に実行される。ステップ100においてA/D変換されたスロットル開度TA（例えば、8ms每にA/D変換する）および機関回転速度NEを取り込み、ステップ102において図10のマップからスロットル開度TAと機関回転速度NEに対応する定常状態での吸気管圧力PMTAを演算する。次のステップ104では、ステップ102で演算された吸気管圧力PMTAとステップ100で取込んだ機関回転速度NEとに基づいて図11に示すマップから重みに関する係数nを演算する。なお、スロットル開度と機関回転速度で重みに関する係数nのマップを定めた場合には、ステップ104でステップ100で取込んだスロットル開度TAと機関回転速度NEとで重みに関する係数nを演算するようにしてもよい。次のステップ106では、ステップ102

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で演算された吸気管圧力PMTAとステップ104で演算された重みに関する係数nと前回のこのルーチンの実行時にステップ106で演算された前回の加重平均値PMSMi-1とを用いて上記で説明した(23)式に従って今回の加重平均値PMSMiを演算する。次のステップ108では今回の加重平均値PMSMiと機関回転速度NEとに基づいて図12に示すマップから基本燃料噴射時間TPを演算する。そして、次のステップ110において吸気温や機関冷却水温等で定まる補正係数FKを基本燃料噴射時間TPに乗算することによって燃料噴射時間TAU演算する。そして、図示しない制御ルーチンにおいて所定クランク角になったときに燃料噴射時間TAUに相当する時間燃料噴射弁を開弁して燃料噴射を実行する。

【0093】図14は所定クランク角毎に割込みによって点火進角θを演算するルーチンを示すものである。なお、図14において図13と同一部分については同一符号を付して説明を省略する。ステップ112では、今回演算された加重平均値PMSMiと機関回転速度NEとにより基本点火進角θBASEを演算する。この基本点火進角θBASEは、演算式によって演算してもよく、また基本燃料噴射時間と同様にマップを作成してこのマップから演算するようにしてもよい。そして、次のステップ114において基本点火進角θBASEに吸気温や機関冷却水温等で定まる補正係数IKを乗算して点火進角θを求める。そして図示しない点火時期制御ルーチンにおいて基本点火進角θでイグナイタをオフすることにより点火を実行する。

【0094】図15(1)、(2)に、加速時における従来での加速増量を行なわない場合の空燃比の変化と本実施の形態での空燃比の変化とを比較して示すと共に燃料噴射量を求めるための本実施の形態での加重平均値PMSMと従来の検出した吸気管圧力PMとの相異を示す。図15から理解されるように、従来例の空燃比は加速時にリーンスパイクが生じているが、本実施の形態の空燃比は略フラットになっている。

【0095】以上説明したように、本実施の形態では実際の吸気管圧力を予測して燃料噴射量と点火時期とを制御することにより圧力センサやフィルタを用いることなく、精度良い燃料噴射量制御と点火時期制御を行なうことができる。

【0096】次に上記内燃機関に本発明を適用した第2の実施の形態を説明する。この実施の形態は加重平均値の演算を所定回繰り返すことによって吸入空気量確定時（吸気弁全閉時）の実際の吸気管圧力を予測し、この予測した吸気管圧力によって燃料噴射量を制御するようにしたものである。図16は所定時間（本実施の形態では8msec）毎に実行して吸入空気量確定時の吸気管圧力の予測値PMSM2を演算するルーチンを示すものである。ステップ200において機関回転速度NEを取込む

と共に、スロットル開度TAのA/D変換を行なってスロットル開度TAを取込む。ステップ202では図10に示すマツブから機関回転速度NEとスロットル開度TAとに対応する定常状態での吸気管圧力PMTAを演算する。次のステップ204では図11に示すマツブから重み付けに関する係数nを演算する。次のステップ206とステップ208では、レジスタPMISM1に記憶されている前回演算した加重平均値PMISM_{i-1}をRAMから読出して上記(23)式に基づいて今回の加重平均値PMISM_iを演算し、ステップ210においてこの加重平均値PMISM_iをレジスタPMISM1に記憶しておく。次のステップ212では、現在時刻から吸気管圧力予測時点までの時間T msecを図16のルーチンの演算周期Δt(=8 msec)で除算することにより演算回数T/Δtを演算する。この予測時間T msecは、現在時刻から吸入空気量確定までの時間すなわち現在時刻から吸気弁が閉じるまでの時間を採用することができ、各気筒独立に燃料を噴射しない場合には燃料噴射弁から燃焼室までの燃料の飛行時間等も考慮して決定されるが、現時点から予測先までのクランク角が同一であってもこの予測時間T msecは機関回転速度が速くなると短くなるので機関回転速度等の運転条件によって可変することが好ましい(例えば、機関回転速度が速くなるに従って短くなる)。次のステップ214では、演算回数T/Δt回上記(23)式の演算を繰り返して実行し、ステップ216においてこの演算した値を吸気管圧力の予測値PMISM2とする。このように加重平均値を繰り返して実行することにより最新の加重平均値は定常運転状態での吸気管圧力値に近づくので、加重平均値の演算回数を上記のように定めることにより現在時刻からT msec先の吸気管圧力(現時点より定常状態に近い状態での吸気管圧力)を予測することができる。

【0097】図17は所定クランク角(例えば、120°CA)毎に燃料噴射時間TAUを演算するルーチンを示すもので、機関回転速度NEとステップ216で演算された吸気管圧力の予測値PMISM2とに基づいて図12に示すマツブから基本燃料噴射時間TPを演算する。そして、ステップ220において上記のステップ110と同様にして燃料噴射時間TAUを演算する。

【0098】なお、現在時刻からT msec経過した時点ではスロットル開度や機関回転速度が変化することがあるため、スロットル開度の微分値や機関回転速度の微分値を用いてT msec先のスロットル開度や機関回転速度を予測してT msec先の定常状態での吸気管圧力を予測し、上記の加重平均値の演算を繰り返すようすれば、さらに精度は向上する。

【0099】上記のように演算したときの加重平均値およびT msec経過後の予測値PMISM2を図18および図19に示す。図18では、16 msec先の予測値と理論値とを示したが、予測値は理論値と略等しくなっている。

なお、スロットル開度のA/D変換タイミングは燃料噴射時間演算タイミングと一致する場合もあるが、最大演算周期Δtに相当する時間である。従って、このずれ時間を平均(0+Δt)/2としてT±Δt/2時間先の吸気管圧力を予測するようにも良い。

【0100】次に、第3実施の形態を説明する。本実施の形態は燃料の機関壁面付着量を予測し燃料噴射量を補正するようにしたものである。

【0101】機関燃焼室へ吸入されない機関壁面に付着している燃料付着量は、吸気弁閉弁時の吸気管圧力によって定まり、例えば、吸気管圧力がPM1の状態からPM2の状態へ加速した場合、各々の吸気管圧力での燃料付着厚さをT1、T2とすると、燃料の付着厚さをT1からT2に増加させるために必要な、壁面への燃料供給量は、スロットル開放速度および燃料噴射回数等に関係なく定まる。そこで、本実施の形態では、ある基準吸気管圧力(例えば、0 mmHgabs)から任意の吸気管圧力まで変化させたときの壁面に供給すべき噴射量の総付着量を図22に示すように吸気弁全閉時での吸気管圧力に対して予めマツブの形でROMに記憶しておく。

【0102】図20は、本実施の形態の所定クランク角(360°CA)毎に実行される燃料噴射量演算ルーチンを示すもので、ステップ230においては上記図16で演算された吸気管圧力の予測値PMISM2と機関回転速度NEとから基本燃料噴射時間TPを上記と同様に演算する。次のステップ232では、吸気温や機関冷却水温等によって定まる燃料噴射量の補正係数FKを算出する。次のステップ234では、図22のマツブから吸気管圧力の予測値PMISM2に対応する機関壁面への燃料付着量FMWETを算出する。そして次のステップ236において基本燃料噴射時間と補正係数FKとを乗算すると共に、今回求めた燃料の付着量FMWETから前回燃料の付着量FMWETOLDを減算した値を補正加算値として加算することにより燃料噴射時間TAUを求める。この補正加算量は吸気管圧力の変化によって生ずる燃料付着量の変化量を表わしている。そしてステップ238において今回求めた燃料の付着量FMWETを前回の付着量FMWETOLDとしてRAMに記憶する。

【0103】以上のように燃料噴射量を制御することによって、図21に示すように斜線で示す部分の量の燃料が増量され、これによって機関の内壁面に燃料付着厚さだけの燃料が付着しても補正加算量によって機関に供給する燃料は要求値になる。なお、図24はスロットル開度、吸気管圧力の予測値および空燃比の変化を示すものであり、本実施の形態では破線で示す従来例のようにリーンスパイクは生ぜず空燃比の変動が少なくなっている。

【0104】次に第4実施の形態を説明する。上記の第3実施の形態では噴射毎の燃料付着量によって燃料噴射

量を制御するようにしてたが、機関壁面への燃料の付着は瞬時には安定しないことを考慮して本実施の形態では各噴射での補正加算量を時間減衰させることによって次回以降の噴射にも反映されることにより燃焼室への燃料の供給量を要求値と等しくするようにしている。図25は本実施の形態の燃料噴射演算ルーチンを示すもので、例えば所定クランク角(360°CA)毎に実行される。なお、図25において図20と同一部分には同一符号を付して説明を省略する。ステップ234で燃料付着量FMWETを算出した後は、ステップ240において以下の式に従って補正加算量FAEを算出する。

$$FAE = 0.2 \cdot FAEOLD + FMWET - FMWETOLD \dots (24)$$

なお、FAEOLDは前回演算した補正加算量、FMWETOLDは前回演算した燃料の壁面への付着量である。

【0105】上記(24)式では、前回の補正加算量FAEOLDに0.2を乗算しているので、前回の補正加算量を80%減衰させて前回の補正加算量の20%を今回 の補正加算量に反映させている。なお、この減衰の仕方は機関によって最適な方法が選択され、上記のように所定クランク角(上記の例では360°CA)毎に所定量づつ減衰させても良く、また所定時間毎に所定量づつ減衰させるようにしても良い。

【0106】次のステップ242では、上記と同様にして基本燃料噴射時間と補正係数FKと補正加算量FAEとを用いて燃料噴射時間TAUを演算する。そして、ステップ244において補正加算量FAEを前回の補正加算量FAEOLDとしてRAMに記憶すると共に、燃料付着量FMWETを前回の燃料付着量FMWETOLDとしてRAMに記憶する。

【0107】なお、上記図22では、吸気弁全閉状態での吸気管圧力に応じて燃料付着量を定める例について説明したが、燃料付着量は機関回転速度に応じても変化するため図23に示すように吸気管圧力と機関回転速度を変数として変化するマップとして記憶させても良い。また、燃料付着量は機関温度によっても変化し、機関温度が低い程燃料付着量が多くなるので更にこの機関温度を変数として定めるようにしても良い。また、上記実施の形態では、加重平均値によって吸気管圧力を予測する例について説明したが、上記(16)式に従って吸気管圧力を予測しても良く、定常状態の吸気管圧力を1次遅れ要素で処理して吸気管圧力を予測しても良い。

【0108】

【発明の効果】以上説明したように本発明は、所定期間先の吸気管圧力の予測値を求めるようにしたので、所定期間として現在から吸入空気量が確定するまでの期間を取り、吸入空気量確定時の実際の吸気管圧力を予測できる、という効果を有する。

【図面の簡単な説明】

【図1】参考例の原理を説明するための線図である。

【図2】吸気系内の実際の吸気管圧力の時間に対する変化を示す線図である。

【図3】従来のスロットル開度と機関回転速度とで定まる吸気管圧力と実際の吸気管圧力との相異を示す線図である。

【図4】従来のスロットル開度と機関回転速度とで定まる燃料噴射量と要求燃料噴射量との相異を示す線図である。

10 【図5】他の参考例を説明するためのプロツク図である。

【図6】更に他の参考例を説明するためのプロツク図である。

【図7】内燃機関を示す概略図である。

【図8】スロットル開度センサの等価回路図である。

【図9】図8の制御回路の詳細を示すプロツク図である。

【図10】定常状態での吸気管圧力のマップを示す線図である。

20 【図11】加重平均値の重み付けに関する係数のマップを示す線図である。

【図12】基本燃料噴射時間のマップを示す線図である。

【図13】第1の実施の形態の燃料噴射量演算ルーチンを示す流れ図である。

【図14】第1の実施の形態の点火進角演算ルーチンを示す流れ図である。

【図15】(1)、(2)は従来例と第1の実施の形態との空燃比および吸気管圧力の変化を示す線図である。

【図16】第2の実施の形態の吸気管圧力の予測値を演算するルーチンを示す流れ図である。

【図17】第2の実施の形態の燃料噴射時間演算ルーチンを示す流れ図である。

【図18】第2の実施の形態の吸気管圧力の予測値等の変化を示す線図である。

【図19】第2の実施の形態の吸気管圧力の予測値等の変化を示す線図である。

【図20】第3の実施の形態の燃料噴射時間演算ルーチンを示す流れ図である。

40 【図21】燃料の壁面付着厚さと吸気管圧力との関係を示す線図である。

【図22】補正噴射量のマップを示す線図である。

【図23】補正噴射量のマップを示す線図である。

【図24】第3の実施の形態の空燃比等の変化を従来例と比較して示す線図である。

【図25】第4の実施の形態の燃料噴射量演算ルーチンを示す流れ図である。

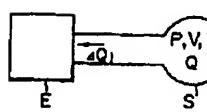
【符号の説明】

8 スロットル弁

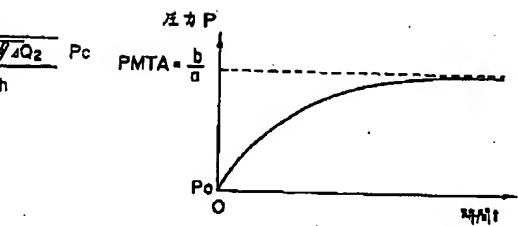
50 10 スロットル開度センサ

4.8 回転角センサ

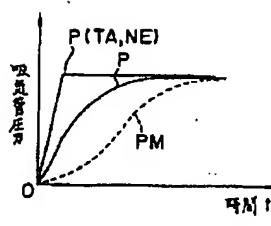
【図1】



【図4】



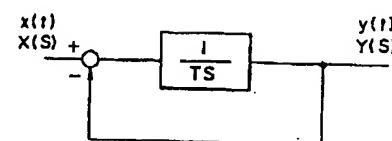
【図2】



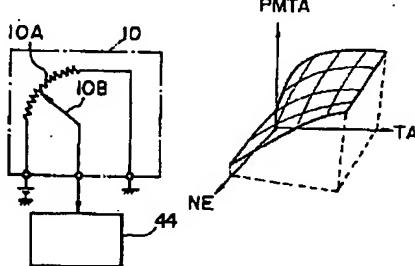
【図3】



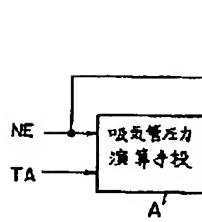
【図5】



【図8】

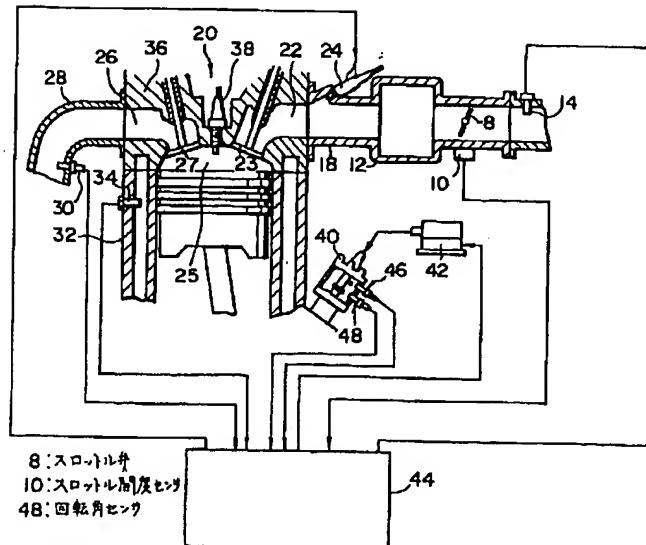


【図10】

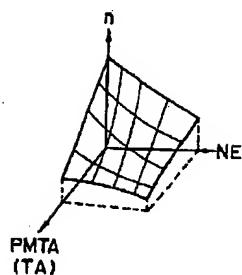


【図6】

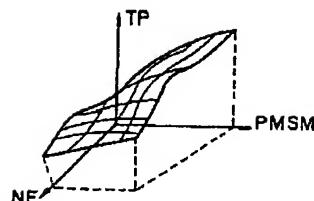
【図9】



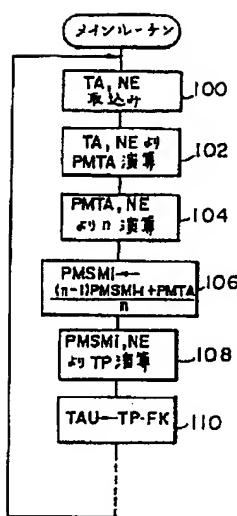
【図11】



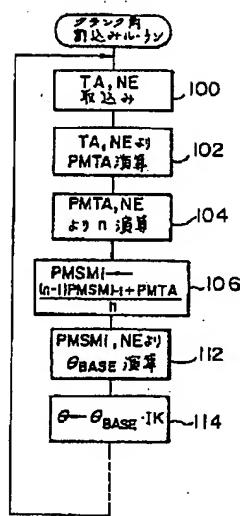
【図12】



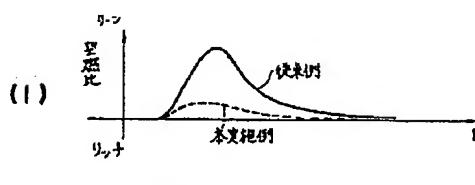
【図13】



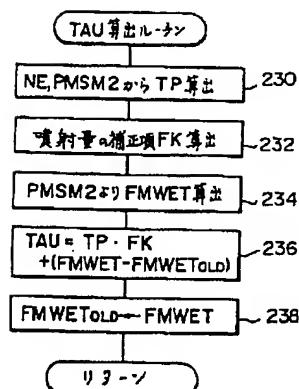
【図14】



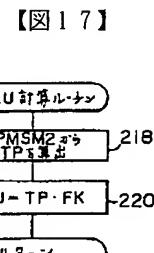
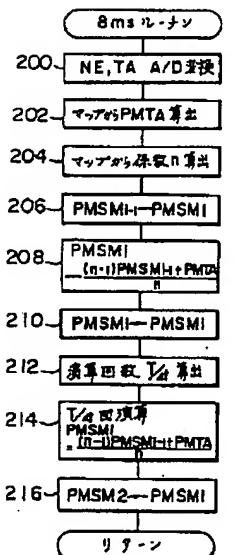
【図15】



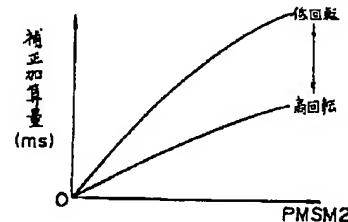
【図20】



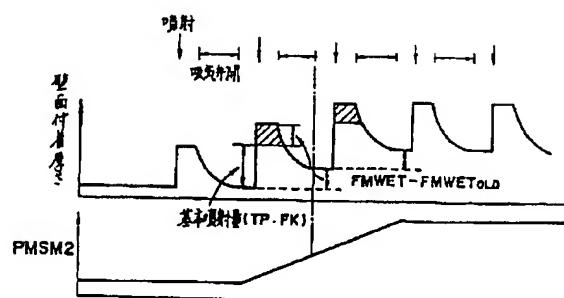
【図16】



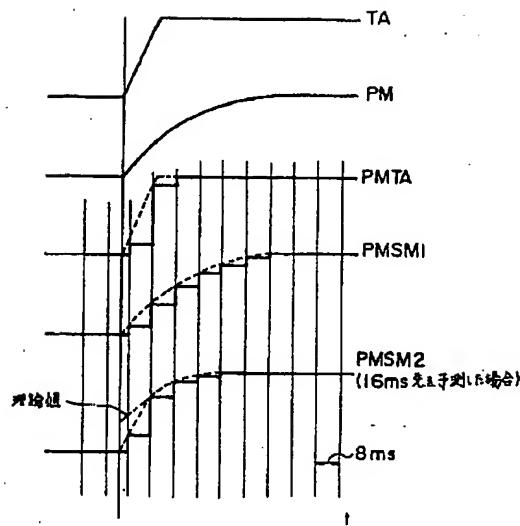
【図23】



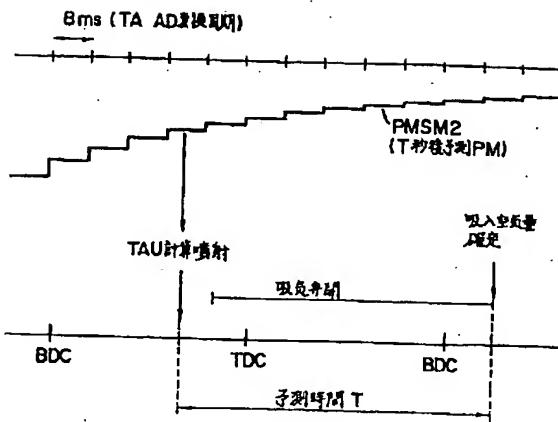
【図21】



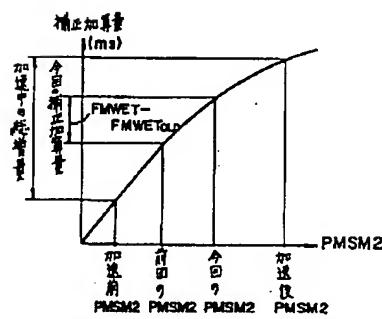
【図18】



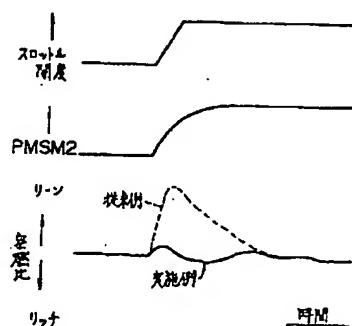
【図19】



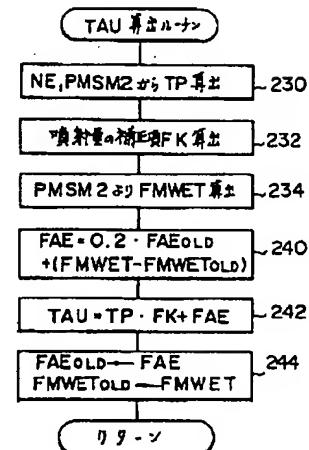
【図22】



【図24】



【図25】



① (JP2000-27692)

It is disclosed that an intake pipe pressure at the time of steady operation (PMTA) is found by using a map, based on an engine speed (NE) and a throttle opening degree (TA), and then an intake pipe pressure at a time subsequent from the present time is predicted by using the PMTA.

Also, refer to English abstract

PATENT ABSTRACTS OF JAPAN

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 F02D 41/04

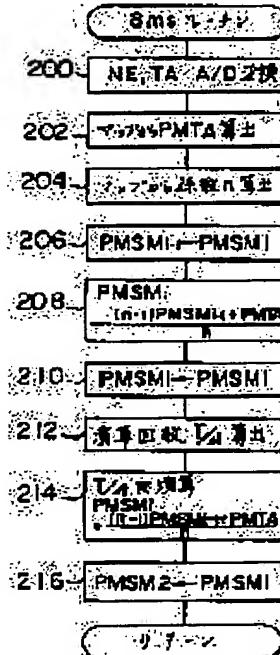
(21)Application number : 11-125268 (71)Applicant : TOYOTA MOTOR CORP
 (22)Date of filing : 05.03.1987 (72)Inventor : OBA HIDEHIRO
 KATOU SENJI

(54) METHOD AND DEVICE FOR DETECTING INTAKE PIPE PRESSURE IN INTERNAL COMBUSTION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To predict an actual intake pipe pressure.

SOLUTION: An engine speed NE and a throttle opening degree TA are read (200). An intake pipe pressure PMTA is computed in a steady-state, corresponding to NE and TA (202). A factor (n) relating to weighing is computed (204). A previously computed weight average value PMSMi-1 is read, and then, a weight average value PMSMi at the present time is computed from $PMSMi=((n-1).PMSMi-1+PMTA)/n$ (206 to 210). A time T msec from the present time to a time for predicting an intake pipe pressure is divided by a computation cycle period $\Delta t (=8$ msec) in a routine so as to compute a frequency $T/\Delta t$ (212). With the repetitions of the above-mentioned computation by the frequency $T/\Delta t$ (214), an intake pipe pressure (intake pipe pressure in a state nearer the steady-state than the present time) is predicted at a time subsequent from the present time by T msec.



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[Date of final disposal for application]	
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[Number of appeal against examiner's decision of rejection]	2001-20049
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[Date of extinction of right]	

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CLAIMS

[Claim(s)]

[Claim 1] Based on a throttle opening and engine rotational speed, the pressure-of-induction-pipe force in a steady state is calculated a predetermined period. Weight of the weighted average efficiency which calculated the multiplier about weight using the time constant about change and said predetermined period of the pressure-of-induction-pipe force of a transient, and was calculated in the past is made heavy. A current weighted average efficiency is calculated using the weighted average efficiency calculated in the past, the pressure-of-induction-pipe force in said steady state, and the multiplier about said weight. An internal combustion engine's pressure-of-induction-pipe force detection approach which uses as a weighted average efficiency which calculated the current weighted average efficiency calculated by the last operation in the case of this repeat ***** operation in the past while repeating this operation and performing the forecast of the pressure-of-induction-pipe force of predetermined period future from this operation event, and is searched for.

[Claim 2] Either [at least] the differential value of a throttle opening or the differential value of engine rotational speed is calculated. Either [at least] the throttle opening in each operation event which repeats said operation and performs it, or engine rotational speed is predicted using this differential value. The pressure-of-induction-pipe force detection approach of an internal combustion engine according to claim 1 which predicts the pressure-of-induction-pipe force in the steady state of said predetermined period future using either [at least] said predicted throttle opening or said while predicting rotational speed in the case of each operation which repeats said operation and performs it.

[Claim 3] The pressure-of-induction-pipe force detection approach of the internal combustion engine according to claim 1 characterized by calculating the multiplier about said weight using a throttle opening and engine rotational speed or the pressure-of-induction-pipe force in a steady state, and engine rotational speed.

[Claim 4] The pressure-of-induction-pipe force detection approach of an internal combustion engine given in any 1 term of claim 1 which sets the multiplier concerning PMTA and said weight in the pressure-of-induction-pipe force in said steady state to n, and is characterized by calculating the current actual pressure-of-induction-pipe force PMSMi from a degree type thru/or claim 3.

PMSMi=(n-1) (-PMSMi-1+PMTA)/n, however PMSMi-1 are the current weighted average efficiencies calculated by the last operation in the case of said each operation performed repeatedly.

[Claim 5] A throttle opening detection means to detect a throttle opening, and a rotational-speed detection means to detect engine rotational speed, A pressure-of-induction-pipe force operation means to calculate the pressure-of-induction-pipe force in a steady state a predetermined period based on said detected throttle opening and said detected engine rotational speed, A weighting-factor operation means to calculate the multiplier about weight using the time constant about change and said predetermined period of the pressure-of-induction-pipe force of a transient, Make heavy weight of the weighted average efficiency calculated in the past, and a current weighted average efficiency is calculated using the weighted average efficiency calculated in the past, the pressure-of-induction-pipe force in said steady state, and the multiplier about said weight. While repeating this operation and performing the forecast of the pressure-of-induction-pipe force of predetermined period future from this operation event, it uses as a weighted average efficiency which calculated the current weighted average efficiency calculated by the last operation in the past in the case of this repeat ***** operation. Pressure-of-induction-pipe force detection equipment of the internal combustion engine having the pressure-of-induction-pipe force forecast prediction means to search for.

[Claim 6] An operation means to calculate either [at least] the differential value of a throttle opening, or the differential value of engine rotational speed, A prediction means to predict either [at least] the throttle

opening in each operation event which repeats said operation and performs it using said calculated differential value, or engine rotational speed, It contains in a pan. Said inlet-pipe forecast prediction means Pressure-of-induction-pipe force detection equipment of an internal combustion engine according to claim 5 which predicts the pressure-of-induction-pipe force in the steady state of said predetermined period future using either [at least] said predicted throttle opening or said predicted engine rotational speed in the case of each operation which repeats said operation and performs it.

[Claim 7] Said weighting-factor operation means is pressure-of-induction-pipe force detection equipment of the internal combustion engine according to claim 5 characterized by calculating the multiplier about said weight using a throttle opening and engine rotational speed or the pressure-of-induction-pipe force in a steady state, and engine rotational speed.

[Claim 8] Said pressure-of-induction-pipe force forecast prediction means is pressure-of-induction-pipe force detection equipment of an internal combustion engine given in any 1 term of claim 5 characterized by calculating the actual pressure-of-induction-pipe force PMSMi current [said] from a degree type when the multiplier concerning PMTA and said weight in the pressure-of-induction-pipe force in said steady state is set to n thru/or claim 7.

PMSMi=(n-1) (-PMSMi-1+PMTA)/n, however PMSMi-1 are the current weighted average efficiencies calculated by the last operation in the case of said each operation performed repeatedly.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Field of the Invention] This invention relates to an internal combustion engine's pressure-of-induction-pipe force detection approach and equipment, and relates to pressure-of-induction-pipe force detection approach and equipment of the internal combustion engine which detects the pressure-of-induction-pipe force based on a throttle opening and engine rotational speed in more detail.

[0002]

[Description of the Prior Art] Conventionally, an internal combustion engine's inlet-pipe detection approach is used for an internal combustion engine's fuel-oil-consumption control approach etc. The conventional internal combustion engine's fuel-oil-consumption control approach detects the pressure-of-induction-pipe force and engine rotational speed, calculates basic fuel injection duration based on this pressure-of-induction-pipe force and engine rotational speed that were detected, amends this basic fuel injection duration according to an intake-air temperature, engine cooling water temperature, etc., finds fuel injection duration, and controls fuel oil consumption by opening the time amount fuel injection valve equivalent to this fuel injection duration. When a time constant processes a pressure-sensor output through the filter of 3 - 5msec, he detects the pressure-of-induction-pipe force, and is trying to calculate basic fuel injection duration in this fuel-oil-consumption control approach, based on this detected pressure-of-induction-pipe force and the engine rotational speed detected by the rotational-speed sensor, in order to remove anchoring and an engine pulsating component for the pressure sensor of a diaphragm type to an inlet pipe.

[0003] However, since the response delay by the diaphragm of a pressure sensor and the response delay by the time constant of a filter exist, a time lag arises in fluctuation of the pressure-of-induction-pipe force detected to fluctuation of the actual pressure-of-induction-pipe force at the time of transient operations at the time of acceleration and deceleration etc. For this reason, in order that a time lag may arise in the pressure-of-induction-pipe force detected to sudden open [of the throttle valve] being carried out at the time of acceleration, and the actual pressure-of-induction-pipe force going up rapidly and basic fuel injection duration may calculate according to the pressure-of-induction-pipe force of a value smaller than the actual pressure-of-induction-pipe force, while an air-fuel ratio becomes exaggerated RIN and acceleration responsibility gets worse, exhaust air emission gets worse. On the contrary, since sudden close [of the throttle valve] is carried out at the time of a slowdown and the pressure-of-induction-pipe force declines rapidly, while basic fuel injection duration will calculate, an air-fuel ratio becomes exaggeratedly rich and drivability gets worse according to the pressure-of-induction-pipe force of a bigger value than the actual pressure-of-induction-pipe force, exhaust air emission gets worse. Rich [exaggerated] and exaggerated performing various kinds of amount amendments of increase and decrease, such as acceleration loading and slowdown loss in quantity, in order to prevent exaggerated RIN, but controlling by all operating range to a target air-fuel ratio thoroughly, since a time lag exists in the pressure-of-induction-pipe force detected by the transient of this air-fuel ratio were impossible.

[0004] Amending this pressure-of-induction-pipe force in consideration of the partial pressure of the exhaust gas at the time of the recirculation of exhaust gas according to the signal which memorizes the pressure-of-induction-pipe force according to the approach (JP,59-28031,A) and throttle opening which calculate basic fuel injection duration based on a throttle opening and engine rotational speed, and engine rotational speed, using a throttle opening as physical quantity which does not have a time lag to a actual value on the other hand, and is acquired from a pressure sensor, and controlling fuel oil consumption is performed (JP,59-39948,A).

[0005]

[Problem(s) to be Solved by the Invention] However, the throttle valve is usually arranged in the location of the upstream which is distant from a pressure-sensor attaching position and an engine combustion chamber, by the time the air which passed the throttle valve reaches to a pressure-sensor attaching position or an engine combustion chamber, a time lag will arise, and since it is the volume between a throttle valve and an inlet valve, as for a throttle opening, a phase will progress to change of a real inhalation air content. For this reason, the pressure-of-induction-pipe force P (TA, NE) defined with a throttle opening and engine rotational speed serves as a value to which the phase progressed from the actual pressure-of-induction-pipe force P, as shown in drawing 3. In addition, PM is pressure-of-induction-pipe force acquired from a pressure sensor. Moreover, as shown in drawing 4, since the phase is progressing to change of a real inhalation air content, the change of a throttle opening of basic fuel oil consumption TP defined with a throttle opening and engine rotational speed (TA, NE) increases more than demand fuel oil consumption. For this reason, if fuel oil consumption is controlled based on a throttle opening and engine rotational speed, fuel oil consumption increases more than desired value at the time of acceleration, an air-fuel ratio becomes exaggeratedly rich at it, fuel oil consumption will become less than desired value at the time of a slowdown, and an air-fuel ratio will become exaggerated RIN. Moreover, when acceleration loading amendment is performed, the slash of drawing 4 comes to show a loading value, and it cannot amend the above-mentioned phase lead lag network.

[0006] It accomplished that this invention should solve the above-mentioned trouble, and aims at offering an internal combustion engine's pressure-of-induction-pipe force detection approach and equipment which enabled it to predict the pressure-of-induction-pipe force which does not have a phase lead lag network and delay using the throttle opening which does not have response delay to change of the actual pressure-of-induction-pipe force, i.e., the actual pressure-of-induction-pipe force.

[0007]

[Means for Solving the Problem] Invention according to claim 1 calculates the pressure-of-induction-pipe force in a steady state a predetermined period based on a throttle opening and engine rotational speed for the above-mentioned object achievement. Weight of the weighted average efficiency which calculated the multiplier about weight using the time constant about change and said predetermined period of the pressure-of-induction-pipe force of a transient, and was calculated in the past is made heavy. A current weighted average efficiency is calculated using the weighted average efficiency calculated in the past, the pressure-of-induction-pipe force in said steady state, and the multiplier about said weight. While repeating this operation and performing the forecast of the pressure-of-induction-pipe force of predetermined period future from this operation event, the current weighted average efficiency calculated by the last operation in the case of this repeat ***** operation is used as a weighted average efficiency calculated in the past, and is calculated.

[0008] Invention according to claim 2 calculates either [at least] the differential value of a throttle opening, or the differential value of engine rotational speed in invention according to claim 1. Either [at least] the throttle opening in each operation event which repeats said operation and performs it, or engine rotational speed is predicted using this differential value. In the case of each operation which repeats said operation and performs it, the pressure-of-induction-pipe force in the steady state of said predetermined period future is predicted using either [at least] said predicted throttle opening or said while predicting rotational speed.

[0009] Invention according to claim 3 calculates the multiplier about said weight in invention according to claim 1 using a throttle opening and engine rotational speed or the pressure-of-induction-pipe force in a steady state, and engine rotational speed.

[0010] In invention given in any 1 term of claim 1 thru/or claim 3, invention according to claim 4 sets the multiplier concerning PMTA and said weight in the pressure-of-induction-pipe force in said steady state to n, and is characterized by calculating the current actual pressure-of-induction-pipe force PMSMi from a degree type.

[0011] $PMSMi = (n-1)(-PMSMi-1 + PMTA)/n$, however PMSMi-1 are the current weighted average efficiencies calculated by the last operation in the case of said each operation performed repeatedly.

[0012] A throttle opening detection means by which invention according to claim 5 detects a throttle opening, A pressure-of-induction-pipe force operation means to calculate the pressure-of-induction-pipe force in a steady state a predetermined period based on a rotational-speed detection means to detect engine rotational speed, and said detected throttle opening and said detected engine rotational speed, A weighting-factor operation means to calculate the multiplier about weight using the time constant about change and said predetermined period of the pressure-of-induction-pipe force of a transient, Make heavy weight of the weighted average efficiency calculated in the past, and a current weighted average efficiency is calculated using the weighted average efficiency calculated in the past, the pressure-of-induction-pipe force in said

steady state, and the multiplier about said weight. While repeating this operation and performing the forecast of the pressure-of-induction-pipe force of predetermined period future from this operation event, it used as a weighted average efficiency which calculated the current weighted average efficiency calculated by the last operation in the past on the occasion of this repeat ***** operation, and it has the pressure-of-induction-pipe force forecast prediction means to search for.

[0013] An operation means by which invention according to claim 6 calculates either [at least] the differential value of a throttle opening, or the differential value of engine rotational speed in invention according to claim 5, A prediction means to predict either [at least] the throttle opening in each operation event which repeats said operation and performs it using said calculated differential value, or engine rotational speed, It contains in a pan and said inlet-pipe forecast prediction means predicts the pressure-of-induction-pipe force in the steady state of said predetermined period future using either [at least] said predicted throttle opening or said predicted engine rotational speed in the case of each operation which repeats said operation and performs it.

[0014] Invention according to claim 7 calculates the multiplier concerning [said weighting-factor operation means] said weight using a throttle opening and engine rotational speed or the pressure-of-induction-pipe force in a steady state, and engine rotational speed in invention according to claim 5.

[0015] When invention according to claim 8 sets the multiplier concerning [said pressure-of-induction-pipe force forecast prediction means] PMTA and said weight in the pressure-of-induction-pipe force in said steady state to n in invention given in any 1 term of claim 5 thru/or claim 7, the actual pressure-of-induction-pipe force PMSMi current [said] is calculated from a degree type.

[0016] $PMSMi = (n-1) (-PMSMi-1 + PMTA)/n$, however PMSMi-1 are the current weighted average efficiencies calculated by the last operation in the case of said each operation performed repeatedly.

[0017] First, the principle which searches for the actual pressure-of-induction-pipe force as reference is explained. As shown in drawing 1, the inhalation-of-air system to Engine's E inlet valve is considered through a surge tank S from throttle-valve Th. The pressure (inlet-pipe absolute pressure) of the air in an inhalation-of-air system P [mmHgabs.], While setting absolute temperature of the air in Q [g] and an inhalation-of-air system to T [**K] and setting atmospheric pressure to Pc [mmHgabs.], the weight of the air which exists the volume of an inhalation-of-air system in V [l] and an inhalation-of-air system The air weight per [which is inhaled from an inhalation-of-air system in Engine's E combustion chamber] unit time amount deltaQ1 [g/sec], Air weight per [which passes throttle-valve Th and is inhaled in an inhalation-of-air system] unit time amount is set to deltaQ2 [g/sec]. As that whose deltaP change the weight of the air of an inhalation-of-air system did $-(\Delta Q_2 - \Delta Q_1)$ Δt change of into minute time amount Δt , and the pressure of the air in an inhalation-of-air system did at this time, when Boyle Charles's principle is applied to the air in an inhalation-of-air system, it comes to be shown in the following (1) types.

[0018]

[Equation 1]

$$\{ P + \Delta P \} V =$$

$$\{ Q + (\Delta Q_2 - \Delta Q_1) \Delta t \} RT \quad \dots (1)$$

[0019] However, R is a gas constant.

[0020] On the other hand, since it is $PV = Q - RT$, if the above-mentioned (1) formula is transformed, the following (2) types will be obtained.

[0021]

[Equation 2]

$$\frac{\Delta P}{\Delta t} = (\Delta Q_2 - \Delta Q_1) \frac{RT}{V} \quad \dots (2)$$

[0022] Air weight deltaQ2 per [which will pass a throttle valve here if psi and opening area (throttle opening) of a throttle valve are set to A for a flow coefficient] unit time amount It is expressed with the following (3) types and is VS about cylinder capacity. Air weight deltaQ1 per [which will be inhaled in an engine's combustion chamber if engine rotational speed is set to NE [rpm] and inhalation effectiveness is set to eta] unit time amount It is expressed with the following (4) types.

[0023]

[Equation 3]

$$\Delta Q_z = \phi \cdot A \sqrt{P_c - P} \quad \dots (3)$$

$$\Delta Q_s = \frac{1}{2} \cdot V_s \cdot \frac{NE}{60} \cdot \eta \cdot P + \frac{1}{RT} \quad \dots (4)$$

[0024] If the above (3) and (4) types are substituted for (2) types, the following (5) types will be obtained.

[0025]

[Equation 4]

$$\begin{aligned} \frac{\Delta P}{\Delta t} &= \frac{RT}{V} \phi A \sqrt{P_c - P} \\ &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot P \quad \dots (5) \end{aligned}$$

[0026] Here, it is [0027] when the limit of $\Delta t \rightarrow 0$ is taken.

[Equation 5]

$$\begin{aligned} \frac{dP}{dt} &= \frac{RT}{V} \phi A \sqrt{P_c - P} \\ &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot P \quad \dots (6) \end{aligned}$$

[0028] It becomes.

[0029] now and pressure P_0 ($\neq PC$) a response in near -- thinking -- a pressure -- P_0 from -- P_0 If it replaces with P of the above-mentioned (6) formula and P_0+P (however, P minute value) is substituted as what changed to $+P$, the following (7) types will be obtained.

[0030]

[Equation 6]

$$\begin{aligned} \frac{dP}{dt} &= \frac{RT}{V} \phi A \sqrt{P_c - P_0 - P} \\ &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \cdot (P_0 + P) \\ &\dots (7) \end{aligned}$$

[0031] It is here and is [0032].

[Equation 7]

$$\begin{aligned} \sqrt{P_c - P_0 - P} &= \sqrt{P_c - P_0} \left(1 - \frac{P}{P_c - P_0} \right)^{\frac{1}{2}} \\ &\approx \sqrt{P_c - P_0} \left(1 - \frac{1}{2} \frac{P}{P_c - P_0} \right) \\ &= \sqrt{P_c - P_0} - \frac{1}{2} \frac{P}{\sqrt{P_c - P_0}} \\ &\dots (8) \end{aligned}$$

[0033] It comes out, and since it is, the above-mentioned (7) formula becomes like the following (9) types.

[0034]

[Equation 8]

$$\begin{aligned}
 \frac{dP}{dt} &= \frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &- \frac{1}{2} \frac{RT}{V} \phi A \frac{P}{\sqrt{P_c - P_0}} \\
 &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta (P_0 + P) \\
 &= - \frac{1}{2} \left(\frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \right. \\
 &\quad \left. + \frac{RT \phi A}{V \sqrt{P_c - P_0}} \right) P \\
 &+ \frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta P_0
 \end{aligned}$$

... (9)

[0035] It is here and is [0036].

[Equation 9]

$$\begin{aligned}
 a &= \frac{1}{2} \left(\frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta \right. \\
 &\quad \left. + \frac{RT \phi A}{V \sqrt{P_c - P_0}} \right) \dots 00
 \end{aligned}$$

$$\begin{aligned}
 b &= \frac{RT}{V} \phi A \sqrt{P_c - P_0} \\
 &- \frac{1}{2} \frac{V_s}{V} \cdot \frac{NE}{60} \cdot \eta P_0 \dots 00
 \end{aligned}$$

[0037] When it carries out, the above-mentioned (9) formula is as follows.

[0038]

[Equation 10]

$$\frac{dP}{dt} = -aP + b \dots 02$$

[0039] If the above-mentioned (12) formula is transformed like the following (13) types, it integrates with both sides and an integration constant is set to C, the following (14) types will be obtained.

[0040]

[Equation 11]

$$\frac{dP}{-aP + b} = dt \dots 03$$

$$-\frac{1}{a} \log (-aP + b) = t + C \dots 04$$

[0041] here -- the time of t=0 -- the initial value of P -- P0 it is -- since -- an integration constant C is as

follows from the above-mentioned (14) formula.

[0042]

[Equation 12]

$$C = -\frac{1}{a} \log \left(-a P_0 + b \right) \dots 05$$

[0043] It is as follows when it asks for P from the above-mentioned (14) formula and (15) types.

[0044]

[Equation 13]

$$P = \frac{b}{a} - \left(\frac{b}{a} - P_0 \right) \cdot e^{-\frac{t}{a}} \dots 06$$

[0045] However, e is the bottom of a natural logarithm.

[0046] Therefore, if the opening area A TA of a throttle valve, i.e., a throttle opening, the engine rotational speed NE, and the elapsed time t from a throttle opening change event are measured and it substitutes for the above-mentioned (16) formula, the actual pressure-of-induction-pipe force P can be searched for. And the operation shown in the following formulas is performed based on the actual pressure-of-induction-pipe force P and the engine rotational speed NE for which carried out in this way and it asked, the basic fuel injection duration TP is found, this basic fuel injection duration TP can be amended according to an intake-air temperature, engine cooling water temperature, etc., fuel injection duration can be found, and the fuel of the amount which an engine demands can be injected by opening the time amount fuel injection valve equivalent to this fuel injection duration.

[0047]

[Equation 14]

$$T P = K \cdot \sqrt{P} / N E$$

[0048] However, K is a constant.

[0049] By the way, when the pressure-of-induction-pipe force P of the above-mentioned (16) formula is expressed with a graph, it comes to be shown in drawing 2, and it is $P=P_0$ at $t=0$. On the limit (steady state) of $t \rightarrow \infty$, it is the output of a first order lag element used as $P=b/a$ (pressure-of-induction-pipe force PMTA in a steady state). Therefore, based on the throttle opening TA and the engine rotational speed NE, the pressure-of-induction-pipe force PMTA in a steady state is calculated, and you may make it calculate the actual pressure-of-induction-pipe force by processing the pressure-of-induction-pipe force PMTA in a steady state by the first order lag element expressed with transfer function [of the following (17) types] $G(s)$.

[0050]

[Equation 15]

$$G(s) = \frac{1}{T s + 1} \dots 07$$

[0051] However, s is the operator of a Laplace transform and T is a time constant.

[0052] That is, the pressure-of-induction-pipe force which makes said elapsed time a variable can also be calculated by processing the pressure-of-induction-pipe force in the steady state which calculated and calculated the pressure-of-induction-pipe force in a steady state based on a throttle opening and engine rotational speed for every predetermined period by the first order lag element.

[0053] Thus, since the actual pressure-of-induction-pipe force is predicted and fuel oil consumption is controlled based on this pressure-of-induction-pipe force and engine rotational speed, the fuel of an amount according to a actual inhalation air content can be injected, an air-fuel ratio can be controlled by this to a target air-fuel ratio, and the excess richness of the air-fuel ratio of a transient and exaggerated RIN can be prevented.

[0054] Next, other examples of reference are explained with reference to drawing 6. As shown in drawing 6, based on the throttle opening TA detected with the throttle opening detection means, and the engine rotational speed detected with the rotational-speed detection means, the pressure-of-induction-pipe force PMTA in a steady state calculates with the pressure-of-induction-pipe force operation means A. As for the pressure-of-induction-pipe force PMTA in the steady state calculated with the pressure-of-induction-pipe

force operation means A, amendment for response delay of the pressure-of-induction-pipe force of a transient is performed by the amendment means B. A first order lag element can be used as this amendment means. Based on the engine rotational speed NE which is inputted into the basic fuel-injection-duration operation means C, and is inputted into the basic fuel-injection-duration operation means, the basic fuel injection duration TP calculates the pressure-of-induction-pipe force amended by the amendment means B. And based on the basic fuel injection duration TP, fuel oil consumption is controlled by the fuel-oil-consumption control means.

[0055] thus -- since neither the pressure sensor nor the filter is used -- structure -- the fuel of the amount which predicts the easy and actual pressure-of-induction-pipe force with a sufficient precision, and an engine demands can be injected.

[0056] Next, an operation is explained for the concrete target of invention according to claim 1.

[0057] In this invention, based on a throttle opening and engine rotational speed, the pressure-of-induction-pipe force in a steady state is calculated a predetermined period, and the multiplier about weight is calculated using the time constant about change and said predetermined period of the pressure-of-induction-pipe force of a transient.

[0058] And make heavy weight of the weighted average efficiency calculated in the past, and a current weighted average efficiency is calculated using the weighted average efficiency calculated in the past, the pressure-of-induction-pipe force in said steady state, and the multiplier about said weight. While repeating this operation and performing the forecast of the pressure-of-induction-pipe force of predetermined period future from this operation event, the current weighted average efficiency calculated by the last operation in the case of this repeat ***** operation is used as a weighted average efficiency calculated in the past, and is calculated.

[0059] That is, if only the count of predetermined obtained by doing the division of the predetermined period a predetermined period, for example repeats the operation of the above-mentioned weighted average efficiency, the pressure-of-induction-pipe force of predetermined period future can be searched for.

Moreover, if a period until the air content inhaled from an operation event as a predetermined period in an engine combustion chamber is decided for example, is taken, the actual pressure-of-induction-pipe force in the event of an inhalation air content being decided can be predicted.

[0060] In addition, basic fuel injection duration is calculated based on the forecast and engine rotational speed of the pressure-of-induction-pipe force of predetermined period future by which prediction was carried out [above-mentioned], and you may make it control fuel oil consumption based on this result of an operation.

[0061] Either [at least] the differential value of a throttle opening or the differential value of engine rotational speed is calculated like claim 2 here. Either [at least] the throttle opening in each operation event which repeats said operation and performs it, or engine rotational speed is predicted using this differential value. You may make it predict the pressure-of-induction-pipe force in the steady state of said predetermined period future using either [at least] said predicted throttle opening or said while predicting rotational speed in the case of each operation which repeats said operation and performs it.

[0062] In this case, since the pressure-of-induction-pipe force in the steady state of predetermined period future is predicted between predetermined periods even when [of a throttle opening and engine rotational speed] either changes at least and the pressure-of-induction-pipe force in a steady state changes, the forecast of the pressure-of-induction-pipe force of predetermined period future can be further predicted from an operation event to high degree of accuracy.

[0063] Moreover, you may make it calculate the multiplier about said weight like claim 3 using a throttle opening and engine rotational speed or the pressure-of-induction-pipe force in a steady state, and engine rotational speed.

[0064] Furthermore, the multiplier concerning PMTA and said weight in the pressure-of-induction-pipe force in said steady state is set to n, and you may make it calculate the present actual pressure-of-induction-pipe force PMSMi from a degree type ((23) types mentioned later) like claim 4.

[0065] $PMSMi = (n-1)(-PMSMi-1 + PMTA)/n$, however PMSMi-1 are the current weighted average efficiencies calculated by the last operation in the case of said each operation performed repeatedly.

[0066] Next, the principle of this invention is explained. When a block diagram expresses a first order lag element, it comes to be shown in drawing 5 , and it is x (t) about an input. It carries out and is y (t) about an output. When it carries out and a time constant is set to T, the relation of I/O of drawing 5 is expressed with the following formulas.

[0067]

[Equation 16]

$$\frac{1}{T} \int_0^t e^{-\frac{t}{T}} d(t) = y(t) \dots (16)$$

$$\frac{1}{T} \int_0^t \{x(t) - y(t)\} d(t) = y(t) \dots (17)$$

$$\begin{aligned} & \frac{1}{T} \int_{t_1}^{t_2} \{x(t) - y(t)\} d(t) \\ & + \frac{1}{T} \int_0^{t_1} \{x(t) - y(t)\} d(t) = y(t) \end{aligned} \dots (18)$$

[0068] Here, it is t_2 . Current operation timing, t_1 If it is the past operation timing, the following (21) types will be obtained.

[0069]

[Equation 17]

$$\begin{aligned} & \frac{1}{T} (t_2 - t_1) \cdot \{x(t_2) - y(t_1)\} \\ & + y(t_1) = y(t_2) \dots (21) \end{aligned}$$

[0070] It sets above (21) and is the current actual pressure-of-induction-pipe force PMSMi in $x(t_2)$ about the pressure-of-induction-pipe force PMTA and y in a steady state (t_2). It is pressure-of-induction-pipe force PMSMi-1 with the actual past, and t_2-t_1 (=deltat) about $y(t_1)$ An operation period, then [0071]

[Equation 18]

$$\begin{aligned} & \frac{\Delta t}{T} (PMTA - PMSM_{i-1}) \\ & + PMSM_{i-1} = PMSM_i \dots (22) \end{aligned}$$

[0072] If a next door and $T/\Delta t = n$, the following (23) types will be obtained.

[0073]

[Equation 19]

$$PMSM_i = \frac{(n-1) \cdot PMSM_{i-1} + PMTA}{n} \dots (23)$$

[0074] That is, the above-mentioned (23) formula is pressure-of-induction-pipe force PMSMi-1 with the actual past. It is the present actual pressure-of-induction-pipe force PMSMi by asking for the weighted average which set weight to $n-1$ and set weight of the pressure-of-induction-pipe force PMTA in a steady state to 1. It is shown that it can calculate. Moreover, the multiplier n about weight is called for by the ratio of a time constant T and operation period $deltat$.

[0075] Therefore, based on a throttle opening and engine rotational speed, the pressure-of-induction-pipe force PMTA in a steady state is calculated by predetermined period $deltat$. The multiplier n about weight is calculated by the time constant T and predetermined period $deltat$ about change of the pressure-of-induction-pipe force of a transient. Weighted-average-efficiency PMSMi-1 calculated in the past The above-mentioned (23) formula is followed by the multiplier n about the pressure-of-induction-pipe force PMTA and weight in weighted-average-efficiency PMSMi-1 and the steady state which made weight heavy and calculated it in the past, and it is a weighted average efficiency PMSMi. If it calculates The current actual

pressure-of-induction-pipe force will be searched for.

[0076] And you may make it control fuel oil consumption based on the basic fuel injection duration which calculated and calculated basic fuel injection duration based on the weighted average efficiency (current actual pressure-of-induction-pipe force) and engine rotational speed which were calculated as mentioned above.

[0077] In addition, time constant $T=1/a$ becomes so small that it becomes so small that the engine rotational speed NE becomes large and the throttle opening TA becomes large so that I may be understood from the above (10) and (16) types. Thus, a time constant is expressed with the function which makes a variable the throttle opening TA and engine rotational speed NE. Therefore, the multiplier n about weight can define operation period Δt with fixed, then the function which makes a variable the throttle opening TA and engine rotational speed NE. In addition, since the pressure-of-induction-pipe force PMTA in a steady state becomes settled uniquely in the throttle opening TA and the engine rotational speed NE, it replaces with the throttle opening TA and the engine rotational speed NE, and you may make it define the multiplier n about weight according to the pressure-of-induction-pipe force PMTA and the engine rotational speed NE in a steady state.

[0078] By the way, it is that the air content supplied to an engine combustion chamber is decided at the inhalation-of-air termination event, at i.e., the inlet-valve clausium time. However, since a time lag will arise if predetermined time of flight is required by the time the fuel injected from the fuel injection valve arrives at a combustion chamber, and fuel oil consumption is calculated when the air content supplied to a combustion chamber is decided while being the predetermined time need, in order to calculate fuel injection duration, in the former, basic fuel injection duration is calculated using the pressure-of-induction-pipe force before the air content supplied to a combustion chamber is decided. For this reason, since fuel oil consumption is controlled by the pressure-of-induction-pipe force of a value smaller than the pressure-of-induction-pipe force which the fuel of the amount which suited the air content actually inhaled by the combustion chamber will not be injected, and an inhalation air content decides at the time of acceleration, an air-fuel ratio serves as Lean, and since fuel oil consumption is controlled by the pressure-of-induction-pipe force of a larger value than the pressure-of-induction-pipe force which an inhalation air content decides at the time of a slowdown, an air-fuel ratio becomes rich.

[0079] The pressure-of-induction-pipe force PMTA in the between steady state from the time of a weighted-average-efficiency operation to the predetermined time point is fixed until an inhalation air content will be decided from the time of a weighted-average-efficiency operation on the other hand, if it assumes that it is that from which the throttle opening TA and the engine rotational speed NE do not change in the above-mentioned (23) formula. Therefore, the actual pressure-of-induction-pipe force at the time of inhalation air content decision can be predicted by repeating and calculating the weighted average efficiency of the above-mentioned (23) formula. For this reason, it asks for the count of an operation by doing the division of the time amount until the air content inhaled by the engine in this invention from the event of calculating the pressure-of-induction-pipe force in a steady state is decided by operation period Δt . When only this count of an operation repeats the operation of a weighted average of the above-mentioned (23) formula, it is desirable to predict the actual pressure-of-induction-pipe force in the event of the air content inhaled, the weighted average efficiency, i.e., the engine, in the event of the air content inhaled by the engine being decided, being decided, and to control fuel oil consumption.

[0080] In addition, although it assumed that it was that from which a throttle opening and engine rotational speed do not change until the air content inhaled by the engine from the time of a fuel-injection-duration operation above was decided When a throttle opening and engine rotational speed change The throttle opening and/or engine rotational speed in the next fuel-injection-duration operation event are predicted using the differential value of the throttle opening in the time of a fuel-injection-duration operation, and/or the differential value of engine rotational speed. If the pressure-of-induction-pipe force in a steady state in case an inhalation air content is decided is predicted, the operation of a weighted average efficiency is repeated as mentioned above and the actual pressure-of-induction-pipe force is predicted, a throttle opening and the precision of the forecast of the actual pressure-of-induction-pipe force at the time of engine rotational-speed fluctuation will improve further (refer to invention of the claim 2 above-mentioned publication).

[0081] Moreover, since all the fuels injected by adhering to engine wall surfaces, such as an intake manifold internal surface, are not supplied to a combustion chamber, as for the fuel injected from the fuel injection valve, it is desirable to amend a part for this fuel adhesion and to control fuel oil consumption. Since its evaporation of a fuel will increase depending on the magnitude of the pressure-of-induction-pipe force if

this fuel coating weight has the small pressure-of-induction-pipe force, fuel coating weight decreases, and since the evaporation of a fuel will decrease if the pressure-of-induction-pipe force is large, fuel coating weight increases. For this reason, in this mode, it is desirable to supply the fuel of the amount corresponding to the actual inhalation air content which predicts the variation of the fuel coating weight from the actual pressure-of-induction-pipe force calculated with a weighted average to an engine wall surface, amends the fuel oil consumption of the amount equivalent to this variation, and is inhaled by the engine to an engine. In addition, the coating weight to the wall surface of a fuel changes also with engine temperature or engine rotational speed (since the evaporation of a fuel will increase if engine temperature is high, fuel coating weight decreases). Since the air rate of flow will become quick, evaporation will increase, if engine rotational speed becomes quick and fuel coating weight becomes there is less, [little] Since you may make it define the variation of fuel coating weight as a function of engine temperature or engine rotational speed and the fuel coating weight to a wall surface is not stabilized in an instant, you may make it make the fuel coating weight when carrying out time amount attenuation and injecting the amount of amendments of fuel oil consumption this time reflect in the injection on and after next time.

[0082] Since the actual pressure-of-induction-pipe force is predicted by calculating a weighted average efficiency a predetermined period in this invention as explained above, the actual pressure-of-induction-pipe force can be predicted without measuring the elapsed time from a throttle opening change event.

[0083] If an air-fuel ratio is controlled by this to a target air-fuel ratio also in a transient, aggravation of acceleration responsibility, drivability, exhaust air emission, etc. can be prevented.

[0084] In addition, since invention according to claim 5 to 8 does so the same operation and effectiveness as invention according to claim 1 to 4, respectively, the explanation is omitted.

[0085]

[Embodiment of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained to a detail below. Drawing 7 is the schematic diagram of the internal combustion engine concerning the gestalt of this operation.

[0086] The throttle valve 8 is arranged at the downstream of an air cleaner (not shown). The throttle opening sensor 10 which detects the opening of a throttle valve 8 is attached in this throttle valve 8. The throttle opening sensor 10 consists of variable-resistance 10A by which the power source was connected to contact 10B and the end which were fixed to the rotation shaft of a throttle valve 8, and the other end was grounded, as shown in the equal circuit of drawing 8. The opening of a throttle valve 8 follows on changing, and the contact condition of contact 10B and variable-resistance 10A changes, and it is constituted so that the electrical potential difference according to the opening of a throttle valve 8 may be obtained from contact 10B. The temperature sensor 14 which consisted of thermistors which detect the temperature of inhalation air is attached in the inlet-pipe wall of the upstream of a throttle valve 8. The surge tank 12 is arranged at the downstream of a throttle valve 8, and the surge tank 12 is opened for free passage by the combustion chamber 25 of the engine body 20 through the intake manifold 18, the inlet port 22, and the inlet valve 23. A fuel injection valve 24 attaches in this intake manifold 24 so that it may correspond to each cylinder -- having -- **** -- each cylinder -- independent -- every [or] cylinder group -- or it is constituted so that fuels can be injected all at once in all cylinders.

[0087] The combustion chamber 25 is opened for free passage by the catalyst equipment (not shown) filled up with the three way component catalyst through the exhaust valve 27, the exhaust port 26, and the exhaust manifold 28. O₂ which outputs the signal which detected the residual oxygen density in exhaust gas, and was reversed bordering on the value corresponding to theoretical air fuel ratio to this exhaust manifold 28. The sensor 30 is attached.

[0088] The cooling coolant temperature sensor 34 which consisted of thermistors which detect the engine cooling water temperature which represents engine temperature so that it may project in an engine water jacket is attached in the cylinder block 32. The ignition plug 38 is attached in the cylinder block 36 so that it may project in each combustion chamber 25. The ignition plug 38 is connected to the control circuit 44 which consisted of microcomputers etc. through the ignitor 42 equipped with the distributor 40 and the ignition coil. The cylinder distinction sensor 46 and the angle-of-rotation sensor 48 which consisted of respectively a signal rotor fixed to the distributor shaft and pickup fixed to distributor housing are attached in the distributor 40. The cylinder distinction sensor 46 outputs a cylinder distinction signal for every 720-degreeCA, and the angle-of-rotation sensor 48 outputs an angle-of-rotation signal for every 30-degreeCA. And engine rotational speed can be calculated from the period of this angle-of-rotation signal.

[0089] The control circuit 44 which consisted of microcomputers etc. is equipped with the buses 75 which connect a microprocessing unit (MPU) 60, read only memory (ROM) 62, random access memory (RAM)

64, backup (BU-RAM) RAM 66, input/output port 68, input port 70, output ports 72 and 74, and these, such as a data bus and a control bus, as shown in drawing 9. The analogue-to-digital (A/D) transducer 78 and the multiplexer 80 are connected to input/output port 68 in order, and while an intake temperature sensor 14 is connected through a buffer 82, the coolant temperature sensor 34 and the throttle opening sensor 10 are connected to this multiplexer 80 respectively through the buffer 84 and the buffer 85. Moreover, it connects with A/D converter 78 and a multiplexer 80, and input/output port 68 is controlled to carry out A/D conversion of the intake temperature sensor 14, coolant temperature sensor 34, and throttle opening sensor 10 output a predetermined period one by one according to the control signal from MPU.

[0090] A comparator 88 and a buffer 86 are minded [70], and it is O2. While a sensor 30 is connected, the cylinder distinction sensor 46 and the angle-of-rotation sensor 48 are connected through the waveform shaping circuit 90. And an output port 72 is connected to an ignitor 42 through the actuation circuit 92, and the output port 74 is connected to the combustion chamber 24 through the actuation circuit 94.

[0091] The map of the pressure-of-induction-pipe force PMTA in the steady state set to the above ROM 62 with the throttle opening TA shown in the program and drawing 10 of the control routine explained below, and the engine rotational speed NE, The map of the multiplier n about the weight defined by the pressure-of-induction-pipe force PMTA in the engine rotational speed NE and the steady state which are shown in drawing 11 (or the throttle opening TA), And the map of the basic fuel injection duration TP defined with the actual pressure-of-induction-pipe force PMSM and the engine rotational speed NE is memorized beforehand. The map of the pressure-of-induction-pipe force PMTA in the steady state shown in drawing 10 sets up the throttle opening TA and the engine rotational speed NE, measures the pressure-of-induction-pipe force corresponding to the throttle opening TA and the engine rotational speed NE which were set up, and is created by using a value when the pressure-of-induction-pipe force is stabilized. execution cycle deltatsec of the operation routine which the map of the multiplier n about the weight shown in drawing 11 measures the time constant T at the time of the response (indicial response) of the pressure-of-induction-pipe force when opening a throttle valve in the shape of a step, and is shown in this measured value and drawing 13 from -- it is created by asking for $T/\Delta t$ ($**n$) corresponding to the engine rotational speed NE and the actual pressure-of-induction-pipe force PMTA (or the throttle opening TA). And the map of the basic fuel injection duration TP of drawing 12 is created by measuring the basic fuel injection duration TP which sets up engine rotational speed and the pressure-of-induction-pipe force, and serves as a target air-fuel ratio.

[0092] Next, the fuel-injection-duration operation routine shown in drawing 13 is explained. This routine is performed by every predetermined time (for example, 8msec). The throttle opening TA (for example, A/D conversion is carried out every 8msec) by which A/D conversion was carried out in step 100, and the engine rotational speed NE are incorporated, and the pressure-of-induction-pipe force PMTA in the steady state corresponding to the throttle opening TA and the engine rotational speed NE is calculated from the map of drawing 10 in step 102. At the following step 104, the multiplier n about weight is calculated from the map shown in drawing 11 based on the pressure-of-induction-pipe force PMTA calculated at step 102, and the engine rotational speed NE incorporated at step 100. In addition, when the map of the multiplier n about weight is defined with a throttle opening and engine rotational speed, you may make it calculate the multiplier n about weight with the throttle opening TA and the engine rotational speed NE which were incorporated at step 100 by step 104. Weighted-average-efficiency PMSMi-1 [last] calculated at step 106 in the following step 106 at the time of activation of the multiplier n about the weight calculated at the pressure-of-induction-pipe force PMTA calculated at step 102, and step 104, and this last routine (23) types which were used and were explained above are followed and it is this weighted average efficiency PMSMi. It calculates. At the following step 108, the basic fuel injection duration TP is calculated from the map shown in drawing 12 based on this weighted average efficiency PMSMi and engine rotational speed NE. And a fuel-injection-duration TAU operation is carried out by carrying out the multiplication of the correction factor FK which becomes settled at an intake-air temperature, engine cooling water temperature, etc. in the following step 110 to the basic fuel injection duration TP. And when it becomes a predetermined crank angle in the control routine which is not illustrated, the time amount fuel injection valve equivalent to fuel injection duration TAU is opened, and fuel injection is performed.

[0093] Drawing 14 shows the routine which calculates an ignition advance theta by interruption for every predetermined crank angle. In addition, in drawing 14, the same sign is attached about the same part as drawing 13, and explanation is omitted. Weighted average efficiency PMSMi calculated at step 112 this time Fundamental-points fire tooth-lead-angle thetaBASE is calculated with the engine rotational speed NE. This fundamental-points fire tooth-lead-angle thetaBASE may be calculated with operation expression, and it creates a map like basic fuel injection duration, and you may make it calculate it from this map. And the

multiplication of the correction factor IK which becomes settled at an intake-air temperature, engine cooling water temperature, etc. in fundamental-points fire tooth-lead-angle thetaBASE in the following step 114 is carried out, and it asks for an ignition advance theta. And ignition is performed by turning off an ignitor by the fundamental-points fire tooth lead angle theta in the ignition-timing control routine which is not illustrated.

[0094] While change of the air-fuel ratio when not performing acceleration loading in the former at the time of acceleration to drawing 15 (1) and (2) and change of the air-fuel ratio in the gestalt of this operation are compared and shown, the weighted average efficiency PMSM in the gestalt of this operation for calculating fuel oil consumption and difference with the pressure-of-induction-pipe force PM which the former detected are shown. Although the RIN spike has produced the air-fuel ratio of the conventional example at the time of acceleration so that I may be understood from drawing 15, the air-fuel ratio of the gestalt of this operation is an abbreviation flat.

[0095] Accurate fuel-oil-consumption control and ignition-timing control can be performed without using a pressure sensor and a filter by predicting the actual pressure-of-induction-pipe force, and controlling fuel oil consumption and ignition timing by the gestalt of this operation, as explained above.

[0096] Next, the gestalt of the 2nd operation which applied this invention is explained to the above-mentioned internal combustion engine. the gestalt of this operation -- the operation of a weighted average efficiency -- predetermined ***** -- the actual pressure-of-induction-pipe force at the time of inhalation air content decision (at the time of an inlet-valve close by-pass bulb completely) is predicted by things, and fuel oil consumption is controlled by this predicted pressure-of-induction-pipe force. Drawing 16 shows the routine which performs to every predetermined time (the gestalt of this operation 8msec(s)), and calculates the forecast PMSM2 of the pressure-of-induction-pipe force at the time of inhalation air content decision. While incorporating the engine rotational speed NE in step 200, A/D conversion of the throttle opening TA is performed and the throttle opening TA is incorporated. At step 202, the pressure-of-induction-pipe force PMTA in the steady state corresponding to the engine rotational speed NE and the throttle opening TA is calculated from the map shown in drawing 10. At the following step 204, the multiplier n about weighting is calculated from the map shown in drawing 11. Weighted-average-efficiency PMSMi-1 calculated last time memorized by the register PMSM1 at following step 206 and following step 208 It reads from RAM, is based on the above-mentioned (23) formula, and is this weighted average efficiency PMSMi. It calculates and is the weighted average efficiency PMSMi of a step 210 odor lever. It memorizes to the register PMSM1. At the following step 212, count T/delta of operation t is calculated by doing the division of the time amount Tmsec of current time to a pressure-of-induction-pipe force prediction event by operation period deltat (=8msec) of the routine of drawing 16. Although the time of flight of the fuel from a fuel injection valve to a combustion chamber etc. is taken into consideration and determined when this prediction time amount Tmsec can adopt time amount until an inlet valve closes, the time amount, i.e., the current time, from current time to inhalation air content decision, and it does not inject a fuel to each cylinder independence Even if the crank angle from this time to a prediction place is the same, it is desirable that it carries out adjustable [of this prediction time amount Tmsec] according to service conditions, such as engine rotational speed, since engine rotational speed will become short if it becomes quick (for example, it shortens as engine rotational speed becomes quick). At the following step 214, the operation of the t count T/delta of operation above-mentioned (23) type is repeated and performed, and let the value which the step 216 odor lever calculated be the forecast PMSM2 of the pressure-of-induction-pipe force. Thus, since the newest weighted average efficiency approaches the pressure-of-induction-pipe force value in a steady operation condition by repeating and performing a weighted average efficiency, the pressure-of-induction-pipe force (pressure-of-induction-pipe force in the condition near [this time] a steady state) of the Tmsec point can be predicted from current time by appointing the count of an operation of a weighted average efficiency as mentioned above.

[0097] Drawing 17 calculates the basic fuel injection duration TP from the map which shows the routine which calculates fuel injection duration TAU to every predetermined crank angle (for example, 120-degreeCA), and is shown in drawing 12 R> 2 based on the engine rotational speed NE and the forecast PMSM2 of the pressure-of-induction-pipe force calculated at step 216. And in step 220, fuel injection duration TAU is calculated like the above-mentioned step 110.

[0098] In addition, since a throttle opening and engine rotational speed may change when Tmsec progress is carried out from current time, if the throttle opening and engine rotational speed of the Tmsec point are predicted using the differential value of a throttle opening, or the differential value of engine rotational speed, and it predicts the pressure-of-induction-pipe force in the steady state of the Tmsec point and is made

to repeat the operation of the above-mentioned weighted average efficiency, precision will improve further. [0099] The weighted average efficiency when calculating as mentioned above and the forecast PMSM2 after Tmsec progress are shown in drawing 18 and drawing 1919. In drawing 18, although the forecast and theoretical value of 16msec point were shown, the forecast has come to spread a theoretical value, abbreviation, etc. In addition, although the A/D-conversion timing of a throttle opening may be in agreement with fuel-injection-duration operation timing, it shifts time to be equivalent to maximum operation period deltat. Therefore, this gap time amount is carried out an average $(0+deltat)/2$. You may make it predict the pressure-of-induction-pipe force $T^{**} deltat / 2$ hour after.

[0100] Next, the gestalt of the 3rd operation is explained. The gestalt of this operation predicts the engine wall surface coating weight of a fuel, and amends fuel oil consumption.

[0101] The fuel coating weight which has adhered to the engine wall surface without being inhaled to an engine combustion chamber If fuel adhesion thickness in each pressure-of-induction-pipe force is set to T1 and T2 when it becomes settled according to the pressure-of-induction-pipe force at the time of inlet-valve clausilium, for example, the pressure-of-induction-pipe force accelerates from the condition of PM1 to the condition of PM2 The amount of fuel supply required in order to make the adhesion thickness of a fuel increase to T2 from T1 to a wall surface becomes settled regardless of throttle opening speed, the count of fuel injection, etc. Then, ROM is made to memorize beforehand the total coating weight of the injection quantity which should be supplied to the wall surface at the time of making it change from a certain criteria pressure-of-induction-pipe force (for example, 0mmHgabs) to the pressure-of-induction-pipe force of arbitration in the form of a map in the gestalt of this operation, to the pressure-of-induction-pipe force in the time of an inlet-valve close by-pass bulb completely, as shown in drawing 22.

[0102] Drawing 20 shows the fuel-oil-consumption operation routine performed by every [of the gestalt of this operation] predetermined crank angle (360-degreeCA), and calculates the basic fuel injection duration TP like the above from the forecast PMSM2 of the pressure-of-induction-pipe force and the engine rotational speed NE which were calculated by above-mentioned drawing 16 in step 230. At the following step 232, the correction factor FK of the fuel oil consumption which becomes settled with an intake-air temperature, engine cooling water temperature, etc. is computed. At the following step 234, the fuel coating weight FMWET from the map of drawing 22 to the engine wall surface corresponding to the forecast PMSM2 of the pressure-of-induction-pipe force is computed. And coating weight FMWETOLD of the coating weight FMWET of the fuel for which it asked this time while carrying out the multiplication of basic fuel injection duration and the correction factor FK in the following step 236 to the last fuel Fuel injection duration TAU is found by adding the subtracted value as an amendment aggregate value. This amount of amendment addition expresses the variation of the fuel coating weight produced by change of the pressure-of-induction-pipe force. And it is the last coating weight FMWETOLD about the coating weight FMWET of the fuel for which it asked in step 238 this time. It carries out and memorizes to RAM.

[0103] By controlling fuel oil consumption as mentioned above, as shown in drawing 21, the quantity of the fuel of the amount of the part shown with a slash is increased, and even if the fuel of only fuel adhesion thickness adheres to an engine's internal surface by this, the fuel supplied to an engine with the amount of amendment addition becomes desired value. In addition, drawing 24 shows change of the forecast of a throttle opening and the pressure-of-induction-pipe force, and an air-fuel ratio, with the gestalt of this operation, like the conventional example shown with a broken line, it was not generated but the fluctuation of an air-fuel ratio of a RIN spike has decreased.

[0104] Next, the gestalt of the 4th operation is explained. As fuel oil consumption is controlled by fuel coating weight for every injection with the gestalt of the 3rd above-mentioned operation, although, adhesion of the fuel to an engine wall surface is made to make the amount of supply of the fuel to a combustion chamber equal to desired value by making it reflected also in the injection on and after next time by carrying out time amount attenuation of the amount of amendment addition in each injection with the gestalt of this operation in consideration of not being stabilized in an instant. Drawing 25 shows the fuel-injection operation routine of the gestalt of this operation, and is performed by every predetermined crank angle (360-degreeCA). In addition, in drawing 25, the same sign is given to the same part as drawing 20, and explanation is omitted. After computing the fuel coating weight FMWET at step 234, in step 240, the amount FAE of amendment addition is computed according to the following formulas.

$$FAE = 0.2 \cdot FAEOLD + FMWET$$

$$- FMWETOLD \dots (24)$$

In addition, FAEOLD The amount of amendment addition, FMWETOLD which were calculated last time It

is the coating weight to the wall surface of the fuel calculated last time.

[0105] The amount FAEOLD of amendment addition last by the above-mentioned (24) formula Since the multiplication of 0.2 is carried out, you attenuate the last amount of amendment addition 80%, and are making it reflected in the amount of amendment addition of this time of the last amount of amendment addition 20%. In addition, the optimal approach is chosen by the engine, and every predetermined crank angle (the above-mentioned example 360-degreeCA) may be made to decrease the method of this attenuation the specified quantity every as mentioned above, and you may make it attenuate it the specified quantity every for every predetermined time.

[0106] At the following step 242, fuel injection duration TAU is calculated using basic fuel injection duration, a correction factor FK, and the amount FAE of amendment addition like the above. And it sets to step 244 and is the last amount FAEOLD of amendment addition about the amount FAE of amendment addition. While carrying out and memorizing to RAM, it is the last fuel coating weight FMWETOLD about the fuel coating weight FMWET. It carries out and memorizes to RAM.

[0107] In addition, since fuel coating weight changes even if it responds to engine rotational speed, it may make the pressure-of-induction-pipe force and engine rotational speed memorize as a map which changes as a variable, as shown in drawing 23 although above-mentioned drawing 22 explained the example which defines fuel coating weight according to the pressure-of-induction-pipe force in an inlet-valve close-by-pass-bulb-completely condition. Moreover, fuel coating weight changes also with engine temperature, and since fuel coating weight increases so that engine temperature is low, you may make it define this engine temperature as a variable further. Moreover, although the gestalt of the above-mentioned implementation explained the example which predicts the pressure-of-induction-pipe force by the weighted average efficiency, the pressure-of-induction-pipe force may be predicted according to the above-mentioned (16) formula, the pressure-of-induction-pipe force of a steady state may be processed by the first order lag element, and the pressure-of-induction-pipe force may be predicted.

[0108]

[Effect of the Invention] As explained above, since this invention calculated the forecast of the pressure-of-induction-pipe force of predetermined period future, if a period until an inhalation air content is decided from current as a predetermined period is taken, it has the effectiveness that the actual pressure-of-induction-pipe force at the time of inhalation air content decision can be predicted.

[Translation done.]

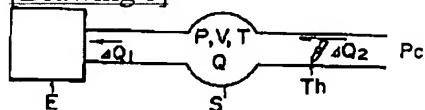
* NOTICES *

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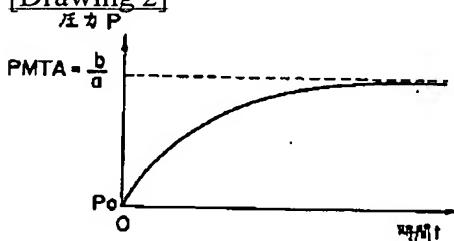
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. *** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

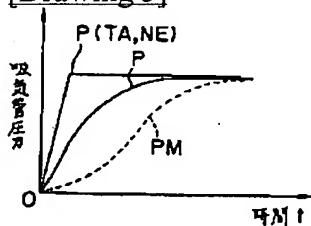
[Drawing 1]



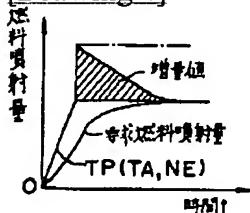
[Drawing 2]



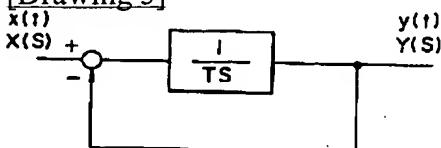
[Drawing 3]



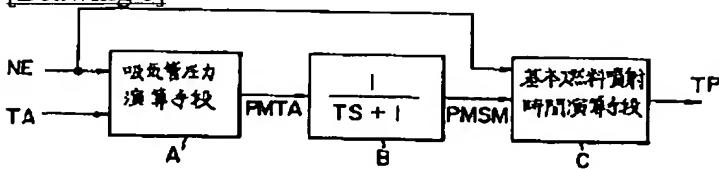
[Drawing 4]



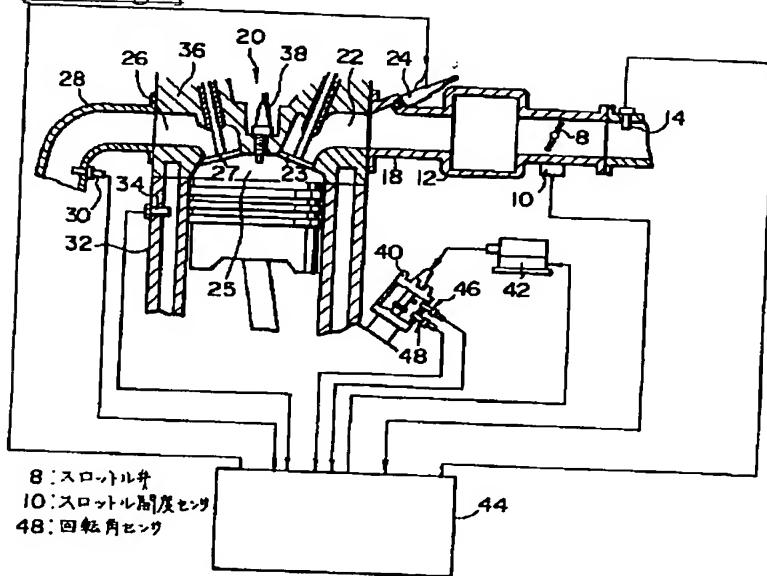
[Drawing 5]



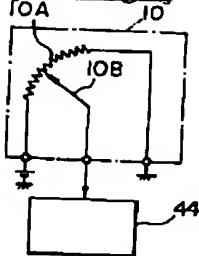
[Drawing 6]



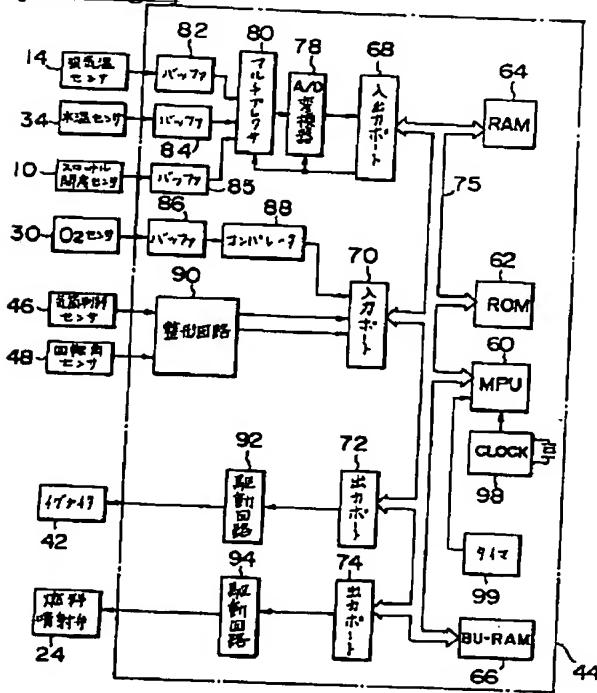
[Drawing 7]



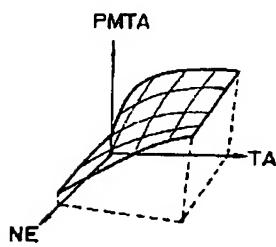
[Drawing 8]



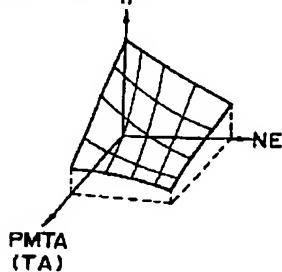
[Drawing 9]



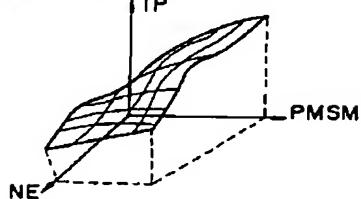
[Drawing 10]



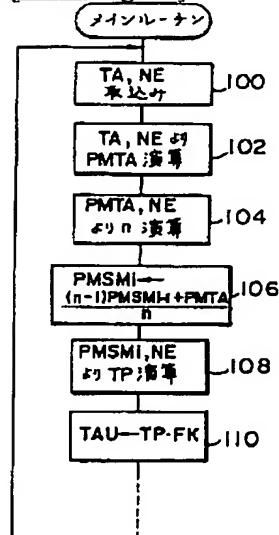
[Drawing 11]



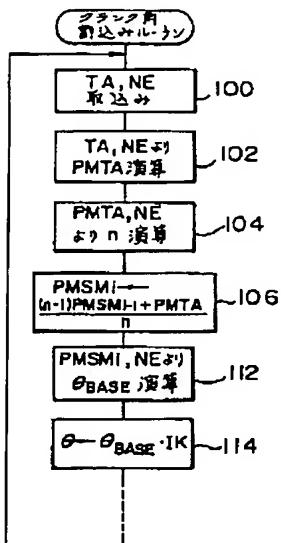
[Drawing 12]



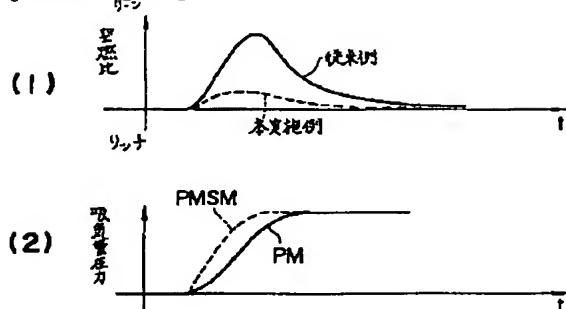
[Drawing 13]



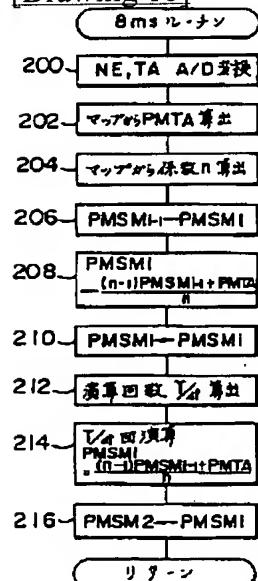
[Drawing 14]



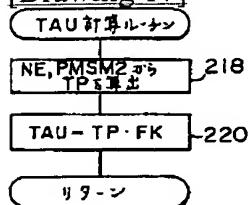
[Drawing 15]

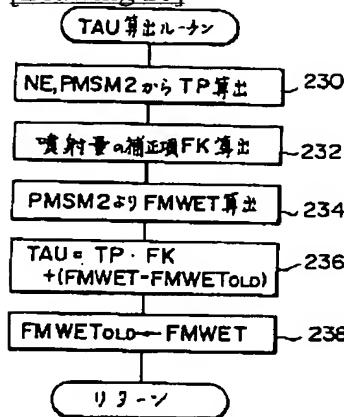
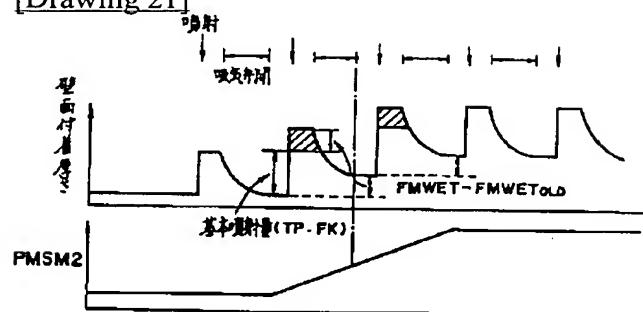
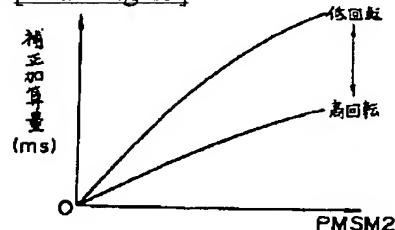
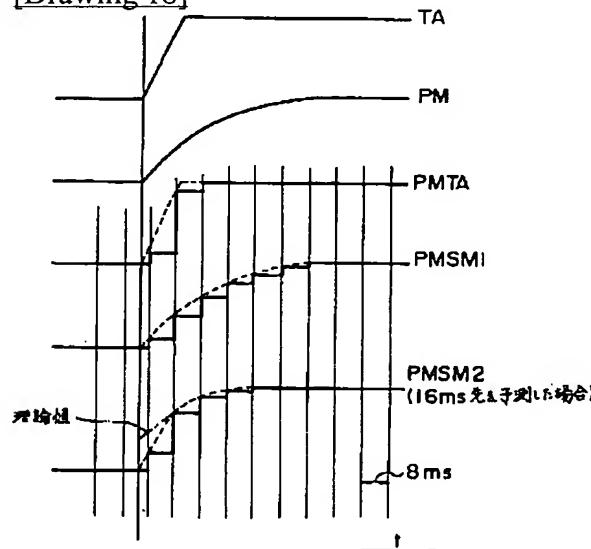


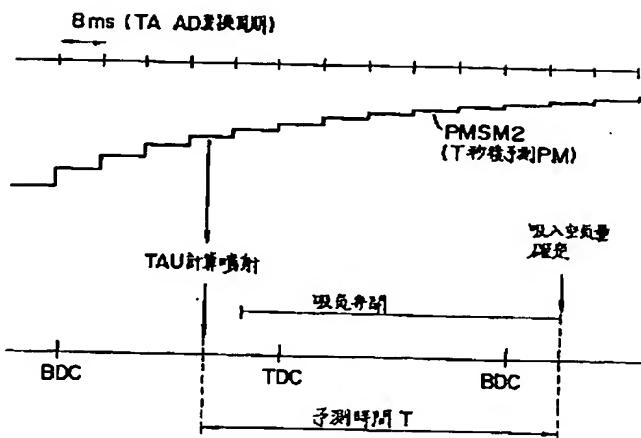
[Drawing 16]



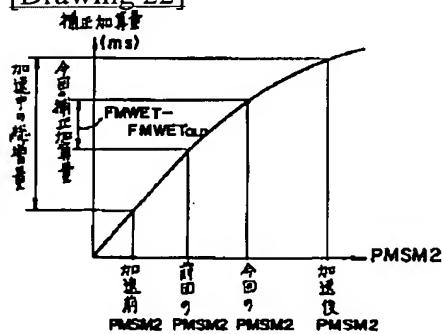
[Drawing 17]



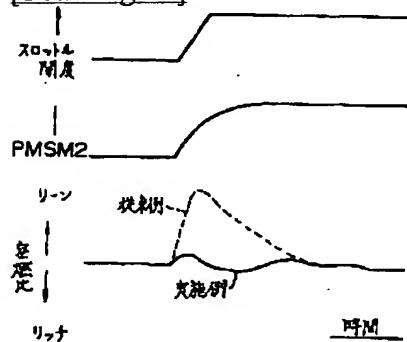
[Drawing 20][Drawing 21][Drawing 23][Drawing 18][Drawing 19]



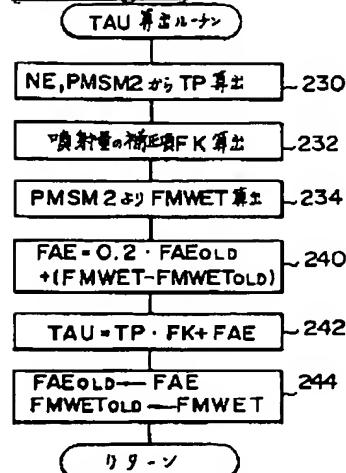
[Drawing 22]



[Drawing 24]



[Drawing 25]



[Translation done.]